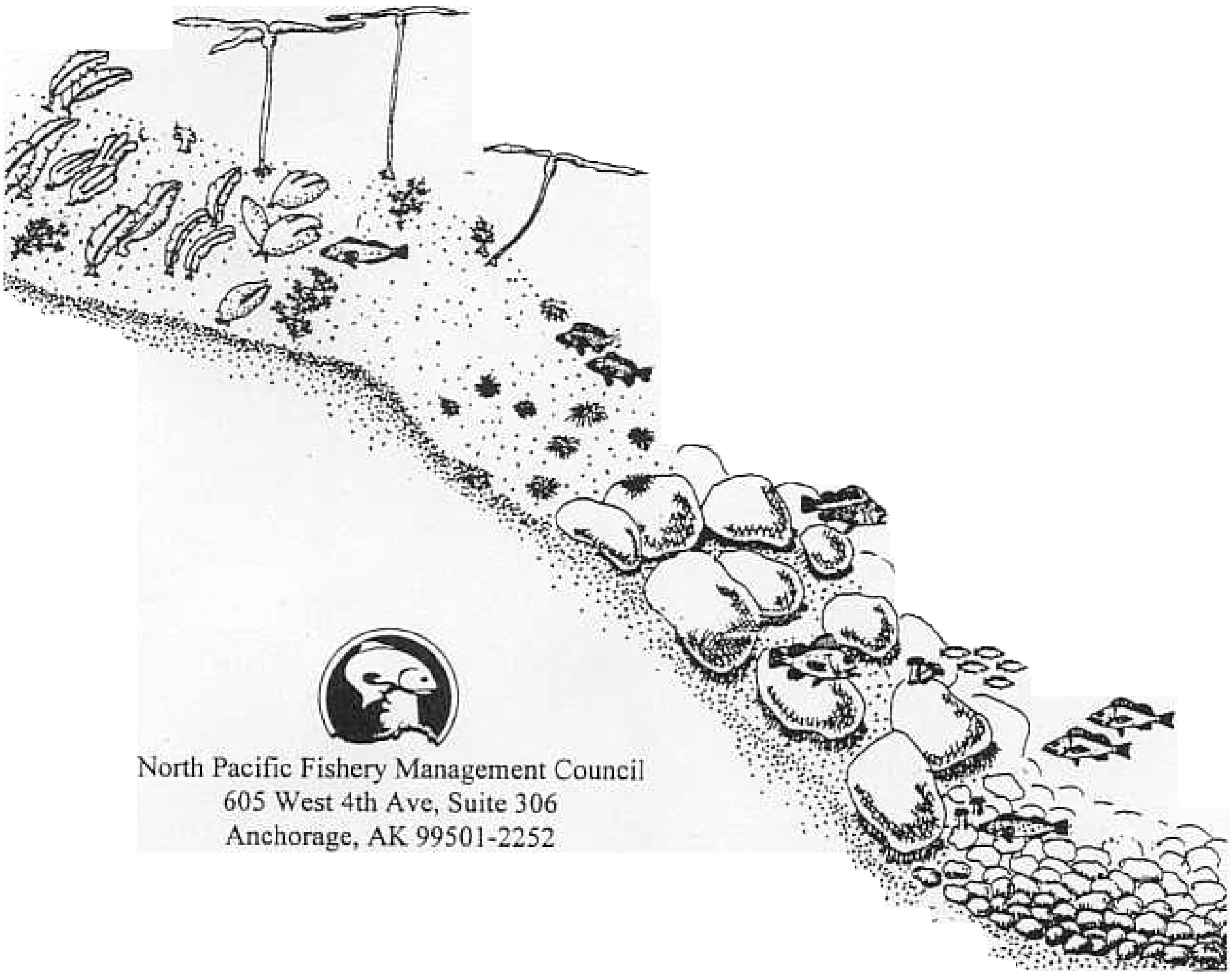
ENVIRONMENTAL ASSESSMENT
for
Amendment 55 to the
Fishery Management Plan for the Groundfish Fishery of the Bering Sea and Aleutian Islands Area;
Amendment 55 to the
Fishery Management Plan for Groundfish of the Gulf of Alaska;
Amendment 8 to the
Fishery Management Plan for the King and Tanner Crab Fisheries
in the Bering Sea/Aleutian Islands;
Amendment 5 to the
Fishery Management Plan for Scallop Fisheries off Alaska;
Amendment 5 to the
Fishery Management Plan for the Salmon Fisheries in the EEZ off the Coast of Alaska

Essential Fish Habitat



January 20, 1999

TABLE OF CONTENTS

Executive Summary

This Environmental Assessment addresses alternatives to protect and conserve habitat of finfish, mollusks, and crustaceans. The Magnuson-Stevens Act mandates that any FMP must include a provision to describe and identify essential fish habitat (EFH) for the fishery, minimize to the extent practicable adverse effects on such habitat caused by fishing, and identify other actions to encourage the conservation and enhancement of such habitat.

Essential fish habitat has been broadly defined by the Act to include "those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity". The Councils are required to amend their fishery management plans by October 1998 to:

- identify and describe EFH for species managed under a fishery management plan;
- describe adverse impacts to that habitat from fishing activities;
- describe adverse impacts to that habitat from non-fishing activities;
- recommend conservation and enhancement measures necessary to help minimize impacts, protect, and restore that habitat; and
- include conservation and enhancement measures necessary to minimize, to the extent practicable, adverse impacts from fishing on EFH.

Once the FMPs are amended with this EFH information, NMFS and the Councils can be more proactive in protecting habitat areas by alerting other federal and state agencies about areas of concern. The NMFS interim final rule on EFH (62 FR 66531 December 19, 1997) encourages coordination between NMFS, the Councils, and other Federal and state agencies. Federal agencies engaging in activities that may adversely affect EFH must consult with NMFS regarding those activities. NMFS must, and the Council may, make suggestions on how to mitigate any potential habitat damage. The Council will be required to comment on any project that may adversely affect salmon habitat or habitat of any other anadromous fish (smelt, steelhead, etc.).

The action identified in this EA is to define and identify EFH for species in the five FMPs (BSAI groundfish, GOA groundfish, BSAI crab, scallops, and salmon). The alternatives analyzed in the EA for defining EFH are the following:

Alternative 1: Status Quo. The FMPs would not be amended to meet Magnuson-Stevens Act requirements (Section 303) for required provisions of FMPs. <u>This is not a viable alternative</u>.

Alternative 2 : (**Preferred**) EFH is defined as all habitat within a general distribution for a species life stage, for all information levels and under all stock conditions. A general distribution area is a subset of a species range. For any species listed under the Endangered Species Act, EFH includes all areas identified as "critical habitat."

Alternative 3: For stocks deemed to be in healthy condition, EFH is defined as a subset of all habitat within a general distribution [e.g., areas of known concentration] in the case of level 2 information or greater for a species life stage. For level 0 and 1 information, EFH is defined as all habitat within a general distribution for a species life stage. For stocks deemed to be in an "overfished" condition, EFH would be defined as the area of general distribution, regardless of information level. For any species listed under the Endangered Species Act, EFH includes all areas identified as "critical habitat."

The consequences of the No Action Alternative are that a program for the conservation and management of EFH in Alaska would not be implemented. Agency decision-makers would not be able to avail themselves of information on the importance of certain habitats to marine fisheries, and their decisions regarding actions that could adversely affect EFH might not give adequate consideration to the need for conservation of particular habitats. Fish populations might remain threatened by habitat loss, and additional fish populations would most likely become threatened as habitat loss continued. Additionally, NMFS would fail to follow a statutory requirement if it chose Alternative 1. All of the alternatives to the status quo would be expected to benefit marine and anadromous fish populations and their habitats, and provide for improved long-term productivity of the fisheries.

Preferred Alternative 2 is the most conservative program for protecting essential fish habitat. Designation of general distribution for species life stages with level 2 and higher information as EFH will trigger more consultations with NMFS on proposed actions that may adversely impact EFH. Alternative 3 would tend to trigger fewer consultations, as somewhat smaller areas would be designated EFH.

Because all stocks of fish managed by FMPs in Alaska are considered to be healthy ("Report to Congress on the Status of Fisheries of the United States"; NMFS 1997), EFH for the species should be a subset of all existing habitat for the species.

Summary of Impacts

None of the alternatives are expected to have a significant impact on endangered, threatened, or candidate species, and none of the alternatives would affect takes of marine mammals. Actions taken to define EFH will not alter the harvest of groundfish, crab, scallops, or salmon.

None of the alternatives contain implementing regulations. Therefore, the Regulatory Flexibility Act does not apply, and review under Executive Order 12866 is not required.

None of the alternatives are likely to significantly affect the quality of the human environment, and the preparation of an environmental impact statement for the proposed action is not required by Section 102(2)(C) of the National Environmental Policy Act or its implementing regulations.

1.0 INTRODUCTION

The groundfish fisheries in the Exclusive Economic Zone (EEZ) (3 to 200 miles offshore) off Alaska are managed under the Fishery Management Plan for Groundfish of the Gulf of Alaska and the Fishery Management Plan for the Groundfish Fisheries of the Bering Sea and Aleutian Islands Area. Both fishery management plans (FMPs) were prepared by the North Pacific Fishery Management Council (Council) under the Magnuson-Stevens Fishery Conservation and Management Act (Magnuson-Stevens Act). The Gulf of Alaska Groundfish (GOA) FMP was approved by the Secretary of Commerce and became effective in 1978, and the Bering Sea and Aleutian Islands Area (BSAI) FMP become effective in 1982.

Salmon fishing in the EEZ off the coast of Alaska is managed under the Fishery Management Plan for the Salmon Fisheries in the EEZ off the Coast of Alaska. This plan was prepared by the Council in 1978. The Secretary of Commerce (Secretary) approved the plan on 3 May 1979, and it was first implemented on 3 May 1979.

The scallop fishery in the EEZ and in Alaskan state waters has been managed by the State of Alaska (State) since a fishery began in 1968. A Federal Fishery Management Plan was adopted by the Council in April 1995 and approved by the National Marine Fisheries Service (NMFS) on July 26, 1995.

The Fishery Management Plan for the Commercial King and Tanner Crab Fisheries in the Bering Sea/Aleutian Islands was approved by the Secretary of Commerce on June 2, 1989.

Actions taken to amend the FMPs must meet the requirements of Federal laws and regulations. In addition to the Magnuson-Stevens Act, the most important of these are the National Environmental Policy Act (NEPA), the Endangered Species Act (ESA), and the Marine Mammal Protection Act (MMPA).

NEPA and E.O. 12866 require a description of the purpose and need for the proposed action as well as a description of alternative actions which may address the problem. This information is included in Section 1 of this document. Section 2 contains information on the biological, environmental and socioeconomic impacts of the alternatives as required by NEPA. Impacts on endangered species and marine mammals are also addressed in this section.

This Environmental Assessment (EA) addresses alternatives for amending the FMPs to meet Magnuson-Stevens Act requirements for essential fish habitat (EFH). In April 1998, the Council reviewed the EFH analysis, which included the proposed closure of the Cape Edgecumbe pinnacles to fishing and anchoring. Based on public testimony and advice from its advisory bodies (the Advisory Panel and Scientific and Statistical Committee), the Council requested that the pinnacle closure be made a separate decision action item within the EFH document. A revised EFH EA document was released for public review on May 12.

In June 1998, the Council reviewed the material and decided to separate the pinnacle closure from EFH provisions, and adopt it as a separate amendment (tentatively identified as Amendment 59 to the GOA groundfish FMP). Based on public testimony and advice from its advisory bodies and NMFS, the Council adopted Alternative 2, for a plan amendment to define EFH as the area identified as general distribution for all information levels and under all stock conditions.

1.1 Purpose of and Need for the Action

The Magnuson-Stevens Act amendments emphasized the importance of habitat protection to healthy fisheries and to strengthen the ability of NMFS and the Councils to protect and conserve habitat of finfish, mollusks, and crustaceans. This habitat is termed essential fish habitat (EFH), and is defined to include "those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity". The Councils are required to amend their fishery management plans by October 1998 to:

- identify and describe EFH for species managed under a fishery management plan;
- describe adverse impacts to that habitat from fishing activities;
- describe adverse impacts to that habitat from non-fishing activities; and
- recommend conservation and enhancement measures necessary to help minimize impacts, protect, and restore that habitat; and
- include conservation and enhancement measures necessary to minimize, to the extent practicable, adverse impacts from fishing on EFH.

Once the FMPs are amended with this EFH information, NMFS and the Councils can be more proactive in protecting habitat areas by alerting other federal and state agencies about areas of concern. Federal agencies engaging in activities that may adversely affect EFH must consult with NMFS regarding those activities. NMFS and the Council may make suggestions on how to mitigate any potential habitat damage. The Council will be required to comment on any project that may affect salmon habitat or habitat of any other anadromous fish (smelt, steelhead, etc.). However, the interim final rule encourages coordination between NMFS and the Councils, and may allow for the Council to delegate the consultation process to NMFS.

The themes of sustainability and risk-averse management are prevalent throughout the Magnuson-Stevens Act, both in the management of fishing practices (e.g., reduction of bycatch and overfishing and consideration of ecological factors in determining optimum yield [OY]) and in the protection of habitats (i.e., prevention of loss of habitats, including EFH). Management of fishing practices and habitat protection are both necessary to ensure long-term productivity of our Nation's fisheries. Mitigation of EFH losses and degradation will supplement the traditional management of marine fisheries. Councils and managers will be able to address a broader range of impacts that may be contributing to the reduction of fisheries resources. Habitats that have been severely altered may be unable to support populations adequately to maintain sustainable fisheries. Councils should recognize that fishery resources are dependent on healthy ecosystems; and that actions which alter the ecological structure and/or functions within the system can disturb the health or integrity of an ecosystem. Excess disturbance, including over-harvesting of key components (e.g., managed species) can alter ecosystems and reduce their productive capacity. Even though traditional fishery management and FMPs have been mostly based on yields of single-species or multi-species stocks, the Magnuson-Stevens Act encourages a broader, ecosystem approach through its EFH requirements. Councils should strive to understand the ecological roles (e.g., prey, competitors, trophic links within food webs, nutrient transfer between ecosystems, etc.) played by managed species within their ecosystems. They should protect, conserve, and enhance adequate quantities of EFH to support a fish population that continues to play its role in maintaining a healthy ecosystem as well as supporting a sustainable fishery.

According to the interim final rule, Councils must identify in FMPs the habitats used by all life history stages of each managed species in their fishery management units (FMUs). Habitats that are necessary to the species for spawning, breeding, feeding, or growth to maturity will be described and identified as EFH. These habitats must be described in narratives (text and tables) and identified geographically (in text and maps) in the FMP. The purpose of mapping is to make it easier to share information with the public, affected parties, and Federal and state agencies, and to facilitate conservation and consultation. EFH that is judged to be particularly important to the long-term productivity of populations of one or more managed species, or to be particularly vulnerable to degradation, should be identified as "habitat areas of particular concern" (HAPC) to help provide additional focus for conservation efforts. After describing and identifying EFH, Councils must assess the potential adverse effects of all fishing-equipment types on EFH and must include management measures that minimize adverse effects, to the extent practicable, in FMPs. Councils are also directed to examine non-fishing sources of adverse impacts that may affect the quantity or quality of EFH and to consider actions to reduce or eliminate the effects. Councils are directed to identify means to further the conservation and enhancement of EFH.

Regulations implementing EFH statutory provisions establish procedures for implementing the coordination, consultation, and recommendation requirements of the Magnuson-Stevens Act. NMFS will coordinate with other Federal and state action agencies by providing them with descriptions and maps of EFH, as well as information on ways to conserve and enhance EFH. The regulations allow Federal agencies to use existing consultation/environmental review procedures or the procedures outlined in the regulation to fulfill their requirement to consult with NMFS on actions that may adversely affect EFH. Consultations may be conducted at a programmatic and/or project-specific level. In cases where effects from an action will be minimal, both individually and cumulatively, a General Concurrence (GC) procedure has been developed to simplify the Federal consultation requirements. Consultation on Federal actions may be conducted under Abbreviated or Expanded Consultation, depending on the severity of the threat to EFH. NMFS anticipates that a majority of Federal actions with the potential for adverse effects on EFH may be addressed through the abbreviated consultation process, the General Concurrence process, or existing review process and Programmatic Consultations. Coordination between NMFS and the Councils is encouraged in the identification of threats to EFH and the development of appropriate EFH conservation recommendations to Federal or state agencies. When NMFS or a Council provides EFH conservation recommendations to a Federal agency, that agency must respond in writing within 30 days. If the action agency's decisions differ from NMFS' conservation recommendations, further review of the decision may be continued by the two agencies, as detailed in the regulations.

1.2 Alternatives Considered

The alternatives proposed to be analyzed in the EA for these amendments are the following:

1.2.1 Alternative 1:

Status Quo. The FMPs would not be amended to meet Magnuson Act requirements (Section 303) for required provisions of FMPs. <u>This is not a viable alternative</u> because the Act mandates that any FMP must include a provision to describe and identify essential fish habitat for the fishery based on the guidelines established by the Secretary under section 305(b)(1)(A), minimize to the extent practicable adverse effects on such habitat caused by fishing, and identify other actions to encourage the conservation and enhancement of such habitat.

1.2.2 Alternative 2 :

(**Preferred**) EFH is defined as all habitat within a general distribution for a species life stage, for all information levels and under all stock conditions. A general distribution area is a subset of a species range. For any species listed under the Endangered Species Act, EFH includes all areas identified as "critical habitat."

1.2.3 Alternative 3:

For stocks deemed to be in healthy condition, EFH is defined as a subset of all habitat within a general distribution [e.g., areas of known concentration] in the case of level 2 information or greater for a species life stage. For level 0 and 1 information, EFH is defined as all habitat within a general distribution for a species life stage. For stocks deemed to be in an "overfished" condition, EFH would be defined as the area of general distribution, regardless of information level. For any species listed under the Endangered Species Act, EFH includes all areas identified as "critical habitat."

1.3 Description and Identification of EFH

1.3.1 Guidance from the Interim Final Rule

Below are excerpts from the interim final rule (62 FR 66531 December 19, 1997) for guidance to the Council on the description and identification of EFH. NMFS recommendations on this subject are included in Chapter 7.0 of this document. These recommendations were based on the EFH Reports, which are incorporated by reference into this analysis. Copies of the following EFH reports are available from the Council office:

1. Essential Fish Habitat Report for the Groundfish Resources of the Bering Sea and Aleutian Islands, April 1, 1998.

2. Essential Fish Habitat Report for the Groundfish Resources of the Gulf of Alaska Region, April 1, 1998.

3. Essential Fish Habitat Report for the Bering Sea and Aleutian Islands King and Tanner Crabs, March 31, 1998.

4. Essential Fish Habitat Report for the Salmon Fisheries in the EEZ off the Coast of Alaska, March 31, 1998.

5. Essential Fish Habitat Report for the Scallop Fisheries off the coast of Alaska, March 31, 1998.

Essential fish habitat means those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity. For the purpose of interpreting the statutory definition of essential fish habitat: “Waters" include aquatic areas and their associated physical, chemical, and biological properties that are used by fish and may include aquatic areas historically used by fish where appropriate; “substrate” includes sediment, hard bottom, structures underlying the waters, and associated biological communities; “necessary” means the habitat required to support a sustainable fishery and the managed species’ contribution to a healthy ecosystem; and "spawning, breeding, feeding, or growth to maturity” covers a species’ full life cycle.

An EFH provision in an FMP must include all fish species in the fishery management unit (FMU). A Council may describe, identify, and protect the habitat of species not in an FMU; however, such habitat may not be considered EFH for the purposes of sections 303(a)(7) and 305(b) of the Magnuson-Stevens

Act. EFH may be described and identified in waters of the United States and the EEZ. Councils may describe, identify, and protect habitats of managed species beyond the EEZ; however, such habitat may not be considered EFH. Activities that may adversely impact such habitat can be addressed through any process conducted in accordance with international agreements between the United States and the foreign nation(s) undertaking or authorizing the action.

Definitions and word usage from the interim final rule.

Adverse effect means any impact which reduces quality and/or quantity of EFH. Adverse effects may include direct (e.g., contamination or physical disruption), indirect (e.g., loss of prey, or reduction in species' fecundity), site-specific or habitat-wide impacts, including individual, cumulative, or synergistic consequences of actions.

Ecosystem means communities of organisms interacting with one another and with the chemical and physical factors making up their environment.

Healthy ecosystem means an ecosystem where ecological productive capacity is maintained, diversity of the flora and fauna is preserved, and the ecosystem retains the ability to regulate itself. Such an ecosystem should be similar to comparable, undisturbed, ecosystems with regard to standing crop, productivity, nutrient dynamics, trophic structure, species richness, stability, resilience, contamination levels, and the frequency of diseased organisms.

All FMPs must describe and identify EFH in text and with tables that provide information on the biological requirements for each life history stage of the species. These tables should summarize all available information on environmental and habitat variables that control or limit distribution, abundance, reproduction, growth, survival, and productivity of the managed species. Information in the tables should be supported with citations.

An initial inventory of available environmental and fisheries data sources relevant to the managed species should be useful in describing and identifying EFH. This inventory should also help to identify major species-specific habitat data gaps. Deficits in data availability (i.e., accessibility and application of the data) and in data quality (including considerations of scale and resolution; relevance; and potential biases in collection and interpretation) should be identified.

To identify EFH, basic information is needed on current and historic stock size, the geographic range of the managed species, the habitat requirements by life history stage, and the distribution and characteristics of those habitats. Information is also required on the temporal and spatial distribution of each major life history stage (defined by developmental and functional shifts). Since EFH should be identified for each major life history stage, data should be collected on, but not limited to, the distribution, density, growth, mortality, and production of each stage within all habitats occupied, or formerly occupied, by the species. These data should be obtained from the best available information, including peer-reviewed literature, data reports and "gray" literature, data files of government resource agencies, and any other sources of quality information.

EFH Information Levels

The interim final rule guidelines specify that the following approach should be used to gather and organize the data necessary for identifying EFH. Information from all levels should be used to identify EFH. The goal of this procedure is to include as many levels of analysis as possible within the constraints of the available data. Councils should strive to obtain data sufficient to describe habitat at the highest level of detail (i.e., Level 4).

(1) Level 1: Presence/absence distribution data are available for some or all portions of the geographic range of the species. At this level, only presence/absence data are available to describe the distribution of a species (or life history stage) in relation to potential habitats. Care should be taken to ensure that all potential habitats have been sampled adequately. In the event

that distribution data are available for only portions of the geographic area occupied by a particular life history stage of a species, EFH can be inferred on the basis of distributions among habitats where the species has been found and on information about its habitat requirements and behavior.

(2) Level 2: Habitat-related densities of the species are available. At this level, quantitative data (i.e., density or relative abundance) are available for the habitats occupied by a species or life history stage. Because the efficiency of sampling methods is often affected by habitat characteristics, strict quality assurance criteria should be used to ensure that density estimates are comparable among methods and habitats. Density data should reflect habitat utilization, and the degree that a habitat is utilized is assumed to be indicative of habitat value. When assessing habitat value on the basis of fish densities in this manner, temporal changes in habitat availability and utilization should be considered.

(3) Level 3: Growth, reproduction, or survival rates within habitats are available. At this level, data are available on habitat-related growth, reproduction, and/or survival by life history stage. The habitats contributing the most to productivity should be those that support the highest growth, reproduction, and survival of the species (or life history stage).

(4) Level 4: Production rates by habitat are available. At this level, data are available that directly relate the production rates of a species or life history stage to habitat type, quantity, quality, and location. Essential habitats are those necessary to maintain fish production, consistent with a sustainable fishery and the managed species' contribution to a healthy ecosystem.

The information obtained through the analysis of this section will allow Councils to assess the relative value of habitats. Councils should interpret this information in a risk-averse fashion, to ensure adequate areas are protected as EFH of managed species. Level 1 information, if available, should be used to identify the geographic range of the species. Level 2 through 4 information, if available, should be used to identify the habitats valued most highly within the geographic range of the species. If only Level 1 information is available, presence/absence data should be evaluated (e.g., using a frequency of occurrence or other appropriate analysis) to identify those habitat areas most commonly used by the species. Areas so identified should be considered essential for the species. However, habitats of intermediate and low value may also be essential, depending on the health of the fish population and the ecosystem. Councils must demonstrate that the best scientific information available was used in the identification of EFH, consistent with national standard 2, but other data may also be used for the identification. If a species is overfished, and habitat loss or degradation may be contributing to the species being identified as overfished, all habitats currently used by the species should be considered essential in addition to certain historic habitats that are necessary to support rebuilding the fishery and for which restoration is technologically and economically feasible. Once the fishery is no longer considered overfished, the EFH identification should be reviewed, and the FMP amended, if appropriate. EFH will always be greater than or equal to aquatic areas that have been identified as "critical habitat" for any managed species listed as threatened or endangered under the Endangered Species Act. Where a stock of a species is considered to be healthy, then EFH for the species should be a subset of all existing habitat for the species.

1.3.2 Specification of EFH Information Levels for Alaska FMP Species

NMFS EFH guidelines provide a typology of information (Level 1 to 4) for classifying the level of information available on the distribution of a life stage. The Alaska technical teams followed these guidelines but deemed it necessary to add another level, "Level 0," as a subset of Level 1, to define a level of knowledge less than Level 1, which requires presence/absence data sufficient for applying analyses of frequency of occurrence. Level 0 information is defined by the Groundfish Technical Team as follows: "No systematic sampling has been conducted for this species and life stage; may have been caught opportunistically in small numbers during other surveys." The BSAI Crab Technical Team used nearly the same definition for Level 0, but specified "research surveys."

Species' life stages with Level 0 information were further subclassified by the technical teams, as presented in the following table:

Classification of EFH level 0 used in the Alaska region EFH determinations based on available information. The classification system used in the Alaska region for levels 1-4 follows NMFS nationwide guidelines.

Level 0	No systematic sampling has been conducted for this species and life stage; may have been caught opportunistically in small numbers during other research.
Level 0a	Some information on a species' life stage upon which to infer general distribution.
Level 0b	No information on the life stage, but some information on a similar species or adjacent life stage from which to infer general distribution.
Level 0c	No information on the actual species' life stage and no information on a similar species or adjacent life stages, or where complexity of a species stock structure prohibited inference of general distribution.

In some cases the technical teams were able to infer EFH for a species' life stage by using Level 0a and 0b information. However, they were not able to infer EFH in Level 0c situations. These cases, in which there was no information on the species' life stage in question, nor on similar species or adjacent life stages, were considered to be research priorities if the life stage was likely to be found in habitat at risk from human activities.

The primary distinction between level 1 and 2 data is how well the available surveys sample a certain species' life history stage. In this report, level 1 will refer to a situation where systematic sampling is adequate to reasonably establish presence or absence and encompasses a significant portion of potential habitat. Where sampling is inadequate to establish absence, and presence is established opportunistically or by studies in only a limited portion of the probable range, a level 0 is designated. For groundfish, crab, and scallop FMP species, the primary source of information that results in an information level of 1 or 2 is the Alaska Fisheries Science Center surveys for stock assessment of adults. As a baseline, team members found that the bottom trawl survey did the best job of sampling adult shallow water flatfish in the Bering Sea. In this case, the sampling gear was relatively efficient at capturing this species, and sampling covered the entire adult distribution. Hence, for adult rock sole, areas of high density could be identified at level 2 information. On the other hand, the bottom trawl and longline surveys were unable to provide level 2 information for adults of a species that ranged deeper than the survey area (e.g., thornyheads), or occurred in areas not thoroughly surveyed (e.g., Atka mackerel). In these cases, fishery observer data sometimes provided adequate information to determine areas of known concentration.

Tables 1.1-1.5 list EFH information levels for groundfish, crab, scallops and salmon in the Alaska region. These levels were proposed by the EFH technical teams and approved by the NMFS Core Team. The technical teams were composed of specialized biologists that study species covered under specific FMPs. The technical teams prepared the EFH reports for each FMP. The Core Team was composed of NMFS personnel involved in fishery management, protected species, and habitat management. One person from the Council staff was on the Core Team, but did not participate in making EFH recommendations. The Core Team prepared the EA.

Table 1.1 Levels of essential fish habitat information currently available for Alaska scallops, by life history stage. Juveniles were subdivided into early and late juvenile stages based on survey and fishery selectivity curves.

Species	Eggs	Larvae	Early Juveniles	Late Juveniles	Adults
Weathervane scallops	0a	0a	0a	1	2
Pink scallops	0a	0c	0a	0a	0a
Spiny scallops	0a	0c	0a	0a	0a
Rock scallops	0a	0c	0a	0a	0a

Note: for the larval stages of Pink, Spiny, and Rock scallops information is insufficient to infer general distributions.
0a: Some information on a species' life stage upon which to infer general distribution.
0c: No information on the actual species' life stage and no information on a similar species or adjacent life stages, or where complexity of a species stock structure prohibited inference of general distribution.

Table 1.2 Levels of essential fish habitat information currently available for BSAI groundfish, by life history stage. Juveniles were subdivided into early and late juvenile stages based on survey selectivity curves.

Species	Eggs	Larvae	Early Juveniles	Late Juveniles	Adults
Pollock	1	1	1	1	2
Pacific cod	0a	0a	0a	1	2
Yellowfin sole	0a	0a	0a	1	2
Greenland turbot	0a	0a	0a	1	2
Arrowtooth flounder	0a	0a	0a	1	2
Rock sole	0a	0a	0a	1	2
Other flatfish	0a	0a	0a	1	2
Flathead sole	0a	0a	0a	1	2
Sablefish	0a	0a	0a	1	2
Pacific ocean perch	-	0a	0a	1	1
Northern rockfish	-	0b	0b	1	1
Shortraker rockfish	-	0b	0a-b	0b	1
Rougheye rockfish	-	0b	0a-b	1	1
Dusky rockfish	-	0b	0b	0a	1
Thornyhead rockfish	0a	0a	0a	0a	1
Atka mackerel	0a	0a	0b	0b	2
Squid	0a	-	0a	0a	0a
Other species					
sculpins	0a	0a	0a	0a	1
skates	0a	-	0a	0a	1
sharks	-	-	0a	0a	0a
octopus	0a	-	0a	0a	0a
squid	0a	-	0a	0a	0a
Forage fish species					
smelts	0a	0a	0a	0a	0a
other forage fish [1,2]	0	0	0	0	0

NOTE: "-" indicates a species that has internal fertilization and bears live young.

[1]Other forage fish includes all members of the lanternfish, deep sea smelt, sand lance, sandfish, gunnel, shanny, krill, bristlemouth families.

[2]For the egg and larvae stages for Myctophids, Bathylagids, Pholids, and Stichaeids, the larvae stage for Sandfish, and the egg, larvae and juvenile stages for gonostomids, information is insufficient to infer general distribution.

0a: Some information on a species' life stage upon which to infer general distribution.

0b: No information on the life stage, but some information on a similar species or adjacent life stage from which to infer general distribution.

Table 1.3 Levels of essential fish habitat information currently available for GOA groundfish, by life history stage.

Species	Eggs	Larvae	Early Juveniles	Late Juveniles	Adults
Pollock	1	1	1	1	2
Pacific cod	0a	0a	0a	1	2
Shallow water flatfish					
Yellowfin sole	0a	0a	0a	1	2
Rock sole	0a	0a	0a	1	2
Deepwater flatfish	0a	0a	0a	0a	1
Arrowtooth flounder	0a	0a	0a	1	2
Rex sole	0a	0a	0a	0a	1
Flathead sole	0a	0a	0a	1	2
Sablefish	0a	0a	0a	1	2
Pacific ocean perch	-	0a	0a	1	1
Northern rockfish	-	0b	0b	1	1
Shortraker rockfish	-	0b	0a-b	0b	1
Rougheye rockfish	-	0b	0a-b	1	1
Yelloweye rockfish	-	0b	0a	1	1
Pelagic shelf rockfish					
Dusky rockfish	-	0b	0b	0a	1
Thornyhead rockfish	0a	0a	0a	0a	1
Atka mackerel	0a	0a	0a	0a	1
Other species					
sculpins	0a	0a	0a	0a	1
skates	0a	-	0a	0a	1
sharks	-	-	0a	0a	0a
octopus	0a	-	0a	0a	0a
squid	0a	-	0a	0a	0a
Forage Fish species					
smelts	0a	0a	0a	0a	0a
other forage fish[1,2]	0	0	0	0	0

NOTE: "-" indicates a species that has internal fertilization and bears live young.
[1]Other forage fish includes all members of the lanternfish, deep sea smelt, sand lance, sandfish, gunnel, shanny, krill, bristlemouth families.
[2]For the egg and larvae stages for Myctophids, Bathylagids, Pholids, and Stichaeids, the larvae stage for Sandfish, and the egg, larvae and juvenile stages for gonostomids, information is insufficient to infer general distribution.
0a: Some information on a species' life stage upon which to infer general distribution.
0b: No information on the life stage, but some information on a similar species or adjacent life stage from which to infer general distribution.

Table 1.4 Levels of essential fish habitat information currently available for BSAI king and Tanner crab, by life history stage. Juveniles were subdivided into early and late juvenile stages based on survey selectivity curves.

Species/Stock	Eggs	Larvae	Early Juveniles[1]	Late Juveniles[2]	Adults
Red King Crab					
Bristol Bay	2	2	1	2	2
Pribilof Islands	2	1	0c	2	2
Norton Sound	2	0c	0c	2	2
Dutch Harbor	2	0c	0c	2	2
Adak	1	0c	0c	0c	1
Blue King Crab					
Pribilof Islands	2	1	2	2	2
St. Matthew I.	1	0c	0c	1	2
St. Lawrence I.	0b	0c	0c	0c	1
Golden King Crab					
Seaguam Pass	2	0c	0c	2	2
Adak	1	0c	0c	1	2
Pribilof Islands	1	0c	0c	1	2
Northern District	0c	0c	0c	0c	0c
Scarlet King Crab					
Bering Sea	0b	0c	0c	0c	1
Adak	0b	0c	0c	0c	1
Dutch Harbor	0b	0c	0c	0c	1
Tanner Crab (C. bairdi)					
Bristol Bay	2	1	1	2	2
Pribilof Islands	2	1	1	2	2
Eastern Aleutians	1	0c	1	2	2
Western Aleutians	0b	0c	0c	0c	1
Snow Crab (C. Opilio)					
Eastern Bering Sea	2	1	1	2	2
Grooved Crab (C. tanneri)					
Bering Sea	0b	0c	0c	0c	1
Eastern Aleutians	0b	0c	0c	0c	1
Western Aleutians	0b	0c	0c	0c	1
Triangle Crab (C. angulatus)					
Bristol Bay	1	0c	0c	0c	1
Eastern Aleutians	1	0c	0c	0c	1

[1] Early juvenile crab are defined as settled crab up to a size approximating age 2.
[2] Late juvenile crab are defined as age 2 through the first size of functional maturity.
Note: For any crab species/stock's life stage at level 0, information was insufficient to infer general distribution (0a).
0b: No information on the life stage, but some information on a similar species or adjacent life stage from which to infer general distribution.
0c: No information on the actual species' life stage and no information on a similar species or adjacent life stages, or where complexity of a species stock structure prohibited inference of general distribution.

Table 1.5 Information levels of EFH assessments currently available for Alaska salmon by regions.

Region I, Southeastern

Species	Eggs and larvae	Juveniles fresh water (fry - smolt)	Juveniles estuarine	Juveniles marine	Adults, immature/ maturing marine	Adults, fresh water
Chinook	1-2	1-2	1-2	1-2	1-2	1-3
Coho	1-3*	2-4*	1-2	1	1	1-3
Pink	1-3	1-3	1-3	1-3	1-3	1-3
Sockeye	1-3	1-4*	1-3	1-2	1-2	1-3
Chum	1-3	1-3	1-3	1-3	1-2	1-3

Region II, Southcentral

Species	Eggs and larvae	Juveniles fresh water (fry - smolt)	Juveniles estuarine	Juveniles marine	Adults, immature/ maturing marine	Adults fresh water
Chinook	1-2	1-3	1	1	1-2	1-3
Coho	1-2	1-2	1-2	1	1-2	1-2
Pink	1-3	1-2	1-2	1-3	1-3	1-3
Sockeye	1-3	1-4	1-2	1	1-2	1-3
Chum	1-3	1-3	1-2	1-3	1-2	1-3

Region III, Southwestern

Species	Eggs and larvae	Juveniles fresh water (fry-smolt)	Juveniles estuarine	Juveniles marine	Adults, immature/ maturing marine	Adults fresh water
Chinook	1-2	1-2	1	1	1-2	1-3
Coho	1-2	1-2	1-2	1	1-2	1-2
Pink	1-2	1-2	1-2	1-2	1-2	1-3
Sockeye	1-3	1-4	1-2	1-2	1-2	1-3
Chum	1-3	1-2	1-2	1-2	1-2	1-3

* Level 3-4 knowledge is available for some stream systems that have been intensively studied, such as the Situk River.

Table 1.5 (continued). Information levels of EFH assessments currently available for Alaska salmon by regions.

Region IV, Western

Species	Eggs and larvae	Juveniles fresh water (fry - smolt)	Juveniles estuarine	Juveniles marine	Adults, immature/ maturing marine	Adults, fresh water
Chinook	1-2	1	1	1	1-2	1-2
Coho	1-2	1	1	1	1	1-2
Pink	1	1	1	1	1	1
Sockeye	1	1	0a	0a	1-2	1
Chum	1-2	0a	0a	0a	1-2	1-2

Region V, Arctic

Species	Eggs and larvae	Juveniles fresh water (fry - smolt)	Juveniles estuarine	Juveniles marine	Adults, immature/ maturing marine	Adults fresh water
Chinook	1	1	1	1	1	1
Coho	1	1	1	0a	1	1
Pink	1	0a	0a	0a	0a	1
Sockeye	1	1	0a	0a	0a	1
Chum	1	0a	0a	0a	0a	1-2

Region VI, Interior

Species	Eggs and larvae	Juveniles fresh water (fry-smolt)	Juveniles estuarine	Juveniles marine	Adults, immature/ maturing marine	Adults fresh water
Chinook	1	1	1	1	1	1
Coho	1	1	1	1	1	1
Pink	1	0a	0a	1	0a	1
Sockeye	1	1	0a	0a	0a	1
Chum	1-2	1	1	1	1	1-2

0a: Some information on a species' life stage upon which to infer general distribution

1.3.3 NMFS Guidance on EFH Determination

The following is an excerpt from the interim final rule (December 1997):

The information obtained through the analysis of available EFH data will allow Councils to assess the relative value of habitats. Councils should interpret this information in a risk-averse fashion, to ensure that adequate areas are protected as EFH of managed species. Level 1 information, if available, should be used to identify the geographic range of the species. Level 2 through 4 information, if available, should be used to identify the habitats valued most highly within the geographic range of the species. If only Level 1 information is available, presence/absence data should be evaluated (e.g., using a frequency of occurrence or other appropriate analysis) to identify those habitat areas most commonly used by the species. Areas so identified should be considered essential for the species. However, habitats of intermediate and low value may also be essential, depending on the health of the fish population and the ecosystem. Councils must demonstrate that the best scientific information available was used in the identification of EFH, consistent with national standard 2, but other data may also be used for the identification.

If a species is overfished, and habitat loss or degradation may be contributing to the species being identified as overfished, all habitats currently used by the species should be considered essential in addition to certain historic habitats that are necessary to support rebuilding the fishery and for which restoration is technologically and economically feasible. Once the fishery is no longer considered overfished, the EFH identification should be reviewed, and the FMP amended, if appropriate.

EFH will always be greater than or equal to aquatic areas that have been identified as "critical habitat" for any managed species listed as threatened or endangered under the Endangered Species Act.

Where a stock of a species is considered to be healthy, then EFH for the species should be a subset of all existing habitat for the species. **[NOTE: No species off Alaska is currently known to be overfished. For 42 rockfish species of very minor commercial and recreational importance (many listed are not harvested at all), the status is unknown. Source: "Report on the Status of Fisheries of the United States," NMFS Report to Congress, October 1997).]**

Ecological relationships among species and between the species and their habitat require, where possible, that an ecosystem approach be used in determining the EFH of a managed species or species assemblage. The extent of the EFH should be based on the judgment of the Secretary and the appropriate Council(s) regarding the quantity and quality of habitat that is necessary to maintain a sustainable fishery and the managed species' contribution to a healthy ecosystem.

If degraded or inaccessible aquatic habitat has contributed to the reduced yields of a species or assemblage, and in the judgment of the Secretary and the appropriate Council(s), the degraded conditions can be reversed through such actions as improved fish passage techniques (for fish blockages), improved water quality or quantity measures (removal of contaminants or increasing flows), and similar measures that are technologically and economically feasible, then EFH should include those habitats that would be essential to the species to obtain increased yields.

1.3.4 Ecological Relationships

Ecological relationships among species and between the species and their habitat require, where possible, that an ecosystem approach be used in determining the EFH of a managed species or species assemblage. The extent of the EFH should be based on the judgment of the Secretary and the appropriate Council(s) regarding the quantity and quality of habitat that is necessary to maintain a sustainable fishery and the managed species' contribution to a healthy ecosystem. If degraded or inaccessible aquatic habitat has contributed to the reduced yields of a species or assemblage, and in the judgment of the Secretary and the appropriate Council(s), the degraded conditions can be reversed through such actions as improved fish passage techniques (for fish blockages), improved water quality or quantity measures (removal of contaminants or increasing flows), and similar measures that are technologically and economically feasible, then EFH should include those habitats that would be essential to the species to obtain increased yields.

Loss of prey is an adverse effect on EFH and a managed species, because one component of EFH is that it be necessary for feeding. Therefore, actions that significantly reduce the availability of a major prey species, either through direct harm or capture, or through adverse impacts to the prey species' habitat that are known to cause a reduction in the population of the prey species may be considered adverse effects on a managed species and its EFH. FMPs should identify the major prey species for the species in the FMU and generally describe the location of prey species' habitat. Actions that cause a reduction of the prey species population, including where there exists evidence that adverse effects to habitat of prey species is causing a decline in the availability of the prey species, should also be described and identified. Adverse effects on prey species and their habitats may result from fishing and non-fishing activities.

FMPs should identify habitat areas of particular concern within EFH. In determining whether a type, or area of EFH is a habitat area of particular concern, one or more of the following criteria must be met:

(i) The importance of the ecological function provided by the habitat.
(ii) The extent to which the habitat is sensitive to human-induced environmental degradation.
(iii) Whether, and to what extent, development activities are, or will be, stressing the habitat type.
(iv) The rarity of the habitat type.

1.3.5 EFH Distribution Maps

The guidelines specify that general distribution and geographic limits of EFH for each life history stage should be presented in FMPs in the form of maps. Ultimately, these data should be incorporated into a geographic information system (GIS) to facilitate analysis and presentation. These maps may be presented as fixed in time and space, but they should encompass all appropriate temporal and spatial variability in the distribution of EFH. If the geographic boundaries of EFH change seasonally, annually, or every decade, these changing distributions need to be represented in the maps. Different types of EFH should be identified on maps along with areas used by different life history stages of the species. The type of information used to identify EFH should be included in map legends, and more detailed and informative maps should be produced as more complete information about population responses (e.g., growth, survival, or reproductive rates) to habitat characteristics becomes available. Where the present distribution or stock size of a species or life history stage is different from the historical distribution or stock size, then maps of historical habitat boundaries should be included in the FMP, if known. The EFH maps are a means to visually present the EFH described in the FMP. If the maps identifying EFH and the information in the description of EFH differ, the description is ultimately determinative of the limits of EFH, as stated in the interim final rule.

Maps for Alaska groundfish, salmon, scallops, and crab are included with the NMFS EFH recommendations in Section 6 of the EA.

1.4 Review of Management Measures to Protect EFH in the Alaska EEZ

Incorporation of habitat concerns into fishery management of North Pacific Fisheries is not a new concept. Numerous actions have been taken based on an explicit habitat policy.

1.4.1 History of NPFMC Habitat Management Policy

Efforts to integrate habitat considerations into the fishery management process go back to the inception of the Magnuson Fishery Conservation and Management Act (MFCMA) in 1976. The Act directs the Councils to recommend management plans for commercial and recreational species of fish occurring in the EEZ throughout the range of the species. Some believed this directive gave the Councils authority to consider fishery related habitat issues within the territorial sea and further inland, even though the Councils clearly did not have jurisdiction within State waters. Although some efforts were made to address significant fishery habitat issues, the Councils and the National Marine Fisheries Service (NMFS) concentrated largely on ocean harvest during the first decade after passage of the Magnuson Act.

In 1983, NMFS adopted a National Habitat Conservation Policy, uniting its MFCMA authority with its advisory responsibilities and authority under the Fish and Wildlife Coordination Act (FWCA) and the National Environmental Policy Act (NEPA). The Habitat Conservation Policy provides guidance to the agency regarding its interactions with the Councils and other Federal and State agencies. It also focuses NMFS's habitat conservation efforts on specific habitat problems affecting fishery resources, marine mammals, and endangered marine species. Although NMFS's policy notifies other agencies and the Councils of NMFS intent, it does not clarify the Councils' role in fishery related habitat issues.

In 1986, Congress amended the Act, essentially codifying elements of the NMFS Habitat Conservation Policy and giving the Regional Fishery Management Councils new authority and responsibility to include "readily available" habitat information in all fishery management plans. The Amendments direct the Councils, with guidance from NMFS, to evaluate the effect that changes in habitat may have on managed fisheries. Furthermore, the 1986 amendments gave the Councils the opportunity to recommend habitat management measures for ongoing and proposed Federal or State activities which could adversely affect fishery resources. Federal agencies are required to respond specifically and substantively to a Council's recommendations within 45 days. The Amendments also encourage the Councils to monitor state activities and to comment on those that could adversely affect Council managed fishery resources.

NPFMC's Habitat Policy Statement of 1988.

The Council shall assume an aggressive role in the protection and enhancement of habitats important to marine and anadromous fishery resources. It shall actively enter Federal decision-making processes where proposed actions may otherwise compromise the productivity of fishery resources of concern to the Council. Recognizing that all species are dependent on the quantity and quality of their essential habitats, it is the policy of the North Pacific Fishery Management Council to:

> Conserve, restore, and maintain habitats upon which commercial, recreational and subsistence marine fisheries depend, to increase their extent and to improve their productive capacity for the benefit of present and future generations. (For purposes of this policy, habitat is defined to include all those things physical, chemical, and biological that are necessary to the productivity of the species being managed.)

This policy shall be supported by three policy objectives which are to:

(1) Maintain the current quantity and productive capacity of habitats supporting important commercial, recreational and subsistence fisheries, including their food base. (This objective will be implemented using a guiding principle of NO NET HABITAT LOSS caused by human activities.)
(2) Restore and rehabilitate the productive capacity of habitats which have already been degraded by human activities.
(3) Maintain productive natural habitats where increased fishery productivity will benefit society.

In September 1988, the North Pacific Fishery Management Council adopted the adjacent policy statement to guide its review of habitat issues. The policy statement itself is augmented by descriptions of the responsibilities, guideline, review process, and definition that will assist the council in executing the habitat policy.

In light of this policy, the North Pacific Fishery Management Council and the National Marine Fisheries Service have enacted certain measures that are consistent with protecting habitat and ecosystem components from potential negative impacts of fisheries. A number of these measures are described below.

1.4.2 Tightly Controlled Harvest Quotas

Total removals of groundfish are controlled by conservative catch quotas. Each year, the NPFMC makes recommendations to the Secretary of Commerce on annual harvest levels for target, prohibited and other species categories. Harvest levels are based on annual stock assessments, which are reviewed by the NPFMC's groundfish plan teams and Scientific and Statistical Committee, and other relevant information on the fisheries. For target species, three harvest levels are set, corresponding to the overfishing level (OFL), the acceptable biological catch (ABC) and total allowable catch (TAC). TACs are essentially annual quotas for the fishery. ABCs generally define acceptable harvest levels from a stock perspective (based on a conservative $F_{40\%}$ strategy for most stocks), and OFL defines the unacceptable harvest level (generally $F_{30\%}$). These quota specifications account for all groundfish harvested, including those fish landed and those discarded (100% mortality for all discards is assumed). To evenly distribute catch and effort, ABCs and TACs may be set for specific regulatory areas, particularly in the GOA. The total TACs of all species, within all regulatory areas, must fall within the optimum yield (OY) range of 116,000 to 800,000 mt for the GOA and 1.4 to 2.0 million mt for the BSAI. Fisheries are closely monitored through reporting requirements and a comprehensive observer program. NMFS is responsible for in-season management of the fisheries, and NMFS closes directed fisheries for each species or complex prior to when the TAC is taken. As such, management has been effective at maintaining catches of groundfish within biologically acceptable levels.

Catch quotas for North Pacific groundfish have been very conservative. For example, in 1981, the Council established a 2 million metric ton cap for Bering Sea and Aleutian Islands groundfish. This limits the total removal of groundfish from the area to 2 million mt per year (allowable sum of all TACs), which has been considerably less than the sum of all ABCs (which has averaged about bout 2.8 million mt). As a result, most groundfish stocks, particularly flatfish stocks, are being underfished now because of the cap. A summary of the 1997 BSAI groundfish catch specifications is shown in the following table. Note that the sum of all ABCs was 2.46 million mt.

In addition to setting maximum harvest levels, fisheries have been both seasonally and spatially allocated to reduce potential impacts of localized depletion. For example, the Bering Sea pollock TAC is split among a winter fishery (A-season) and a late summer fishery (B-season). In the GOA, pollock is spatially apportioned into regional areas. Regional apportionment is also done for Atka mackerel in the Aleutian Islands. Because Atka mackerel and pollock are important prey for higher trophic levels, these measures reduce the impacts of harvesting on the ecosystem.

Exploitable biomass and harvest specifications (mt) of Bering Sea and Aleutian Islands groundfish, 1997. Biomass listed is that projected for 1997.

Species	Area	Biomass	OFL	ABC	TAC
Pollock	BS	6,120,000	1,980,000	1,130,000	1,130,000
	AI	100,000	38,000	28,000	28,000
	Bogoslof	558,000	43,800	32,100	1,000
Pacific Cod	BSAI	1,590,000	418,000	306,000	270,000
Yellowfin sole	BSAI	2,530,000	339,000	233,000	230,000
Greenland turbot	BSAI	118,000	22,600	12,350	9,000
Arrowtooth flounder	BSAI	587,000	167,000	108,000	20,760
Rock sole	BSAI	2,390,000	427,000	296,000	97,185
Flathead sole	BSAI	632,000	145,000	101,000	43,500
Other flatfish	BSAI	616,000	150,000	97,500	50,750
Sablefish	BS	17,900	2,750	1,308	1,100
	AI	18,600	2,860	1,367	1,200
Pacific Ocean Perch	BS	72,500	5,400	2,800	2,800
	AI	324,000	25,300	12,800	12,800
Sharpchin/Northern	AI	96,800	5,810	4,360	4,360
Shortraker/Rougheye	AI	45,600	1,250	938	938
Other red rockfish	BS	29,700	1,400	1,050	1,050
Other rockfish	BS	7,100	497	373	373
	AI	13,600	952	714	714
Atka mackerel	AI	450,000	81,600	66,700	66,700
Squid	BSAI	n/a	2,620	1,970	1,970
Other species	BSAI	688,000	138,000	25,800	25,800
TOTAL (all species)	BSAI	17,004,800	3,998,839	2,464,130	2,000,000

The Council also has a record of rebuilding depleted stocks. Conservation policies adopted by the Council in the 1980s had the effect of restoring depleted stocks such as yellowfin sole and sablefish. In 1993, the Council established an explicit rebuilding plan for GOA Pacific ocean perch. This stock had been depleted by foreign fisheries in the mid-1960s. The plan established a target spawning biomass and a rebuilding schedule based on a very conservative harvest strategy. A follow-up amendment (Amendment 38) allows the removal rates to be set even more conservatively to hasten rebuilding of this stock. Because Pacific ocean perch are a long-lived component of the GOA fish community, the rebuilding plan falls within the realm of an ecosystem-based management strategy.

In 1996, the Council adopted a more conservative overfishing definition under Amendment 44/44 to the BSAI and GOA groundfish fishery management plans. Overfishing is a level or rate of fishing mortality that jeopardizes the long-term capacity of a stock to produce maximum sustainable yield on a continuing basis. The new definition instituted new safeguards against overly aggressive harvest rates, particularly under conditions of high uncertainty or low stock size. The new definition sets a maximum allowable fishing rate as prescribed through a set of six tiers corresponding to information availability. In addition, a buffer will be maintained between acceptable biological catch (ABC) and the overfishing level. Under current stock conditions, ABCs were reduced for flatfish, sablefish, and many rockfish species in both the GOA and BSAI areas.

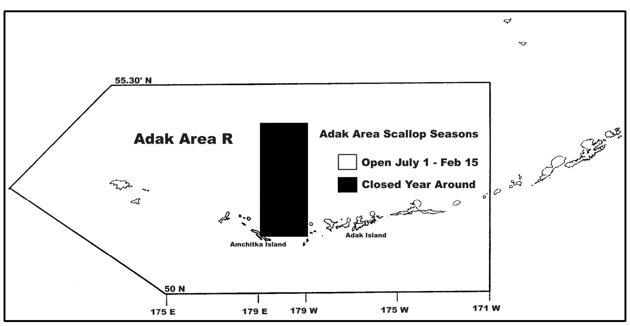
In 1997, the Council adopted, and the Secretary has since approved, amendments to the GOA and BSAI groundfish FMPs that prohibit directed fishing for forage fish (smelts, in particular). The FMPs now define smelts to include capelin (*Mallotus villosus*), rainbow smelt (*Osmerus mordax*), and eulachon (*Thaleichthys pacificus*), which are important prey for groundfish, seabirds, and marine mammals. Prior to the amendment, smelts were included in the "other species" directed category and assigned a TAC for the category as a whole. The Council took this proactive approach by preventing fisheries for these important species from expanding or developing.

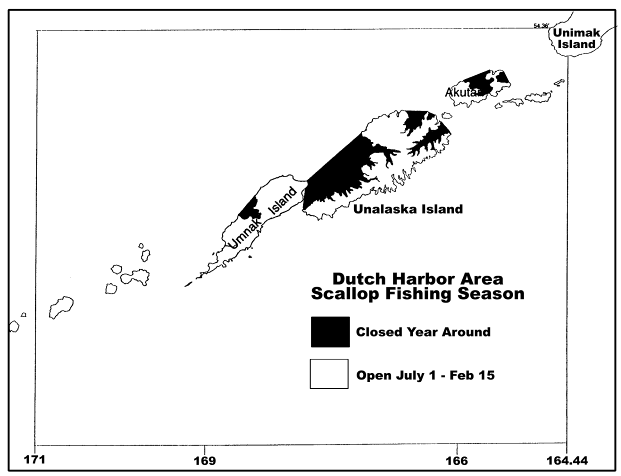
1.4.3 Area Closures

The Council and the Alaska Board of Fisheries have adopted and NMFS has implemented numerous area closures for fishing to protect habitat for fish, crabs, and marine mammals. A summary is provided below.

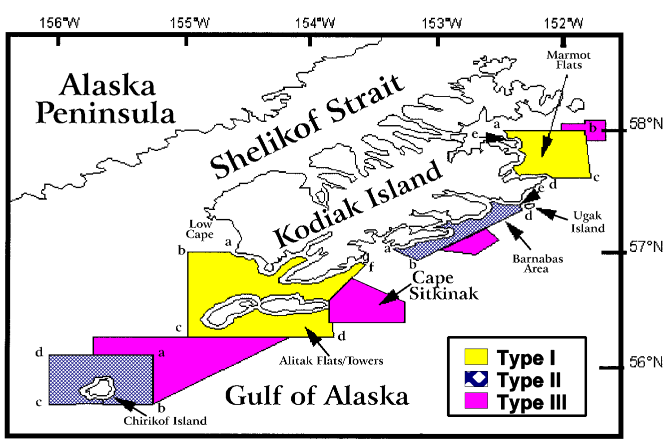
<u>Crab Habitat</u> - Several areas of the Bering Sea have been closed to groundfish trawling and scallop dredging to reduce potential adverse impacts on the habitat for crab and other resources. Beginning in 1995, the Pribilof Islands Conservation Area was closed to all trawling and dredging year-round to protect blue king crab habitat (primarily shell hash). Also beginning in 1995, the Red King Crab Savings Area was established as a year-round bottom trawl and dredge closure area. This area is known to have high densities of adult red king crab. To protect juvenile red king crab and critical rearing habitat (stalked ascidians and other living substrate), another year-round closure to all trawling was implemented for the nearshore waters of Bristol Bay. Specifically, the area east of 162° W (i.e., all of Bristol Bay) is closed to trawling and dredging, with the exception of an area bounded by 159° to 160° W and 58° to 58°43' N that remains open to trawling during the period April 1 to June 15 each year.

The figures below show locations of other areas in the BSAI closed to scallop dredging.





There are also trawl and dredge closure areas in the Gulf of Alaska to protect king crab and crab habitat. In the Kodiak Island area, trawl closure areas were designed based on the use of areas by crab life stage and level of recruitment. Three types of areas are designated. Type I areas have very high king crab concentrations and, to promote rebuilding of the crab stocks, are closed all year to all trawling except with pelagic gear. Type II areas have lower crab concentrations and are only closed to non-pelagic gear from February 15 through June

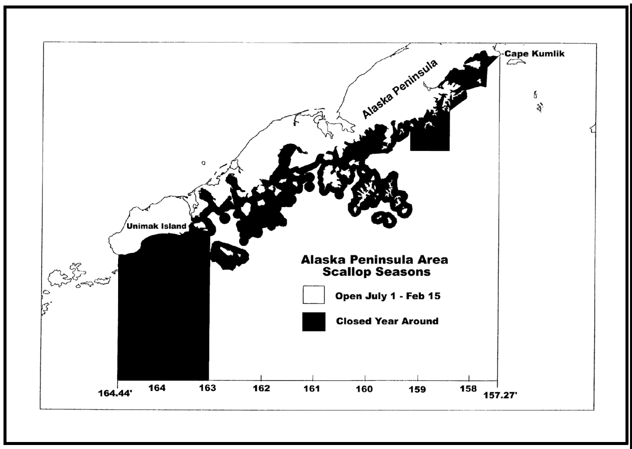


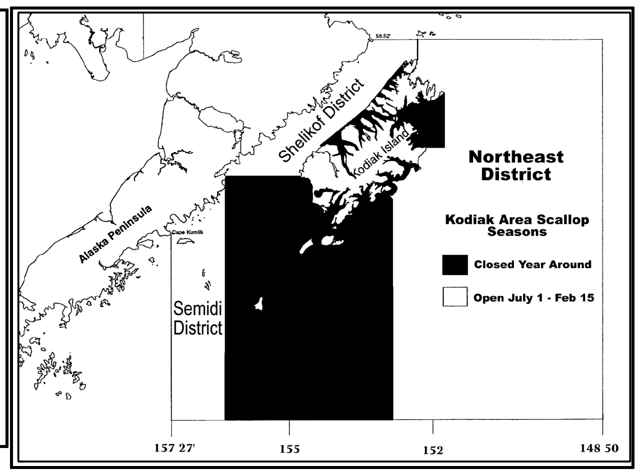
Location of trawl closure areas in the Gulf of Alaska to protect red king crabs.

15. Type III areas are adjacent to Type I and II areas and have been identified as important juvenile king crab rearing or migratory areas. Type III areas become operational following a determination that a "recruitment event" has occurred. The Regional Director will classify the expanded Type III area as either Type I or II, depending on the information available. A "recruitment event" is defined as the appearance of female king crab in substantially increased numbers (when the total number of females estimated for a given district equals the number of females established as a threshold criterion for opening that district to commercial crab fishing). A recruitment event closure will continue until a commercial crab fishery opens for that district or the number of crabs drops below the threshold level for that district.

No trawling is allowed in the eastern Gulf of Alaska as of March 23, 1998. This area was closed as part of the license limitation system that was adopted as GOA Groundfish FMP Amendment 41.

The figures below show areas closed to scallop dredging in the Gulf of Alaska.





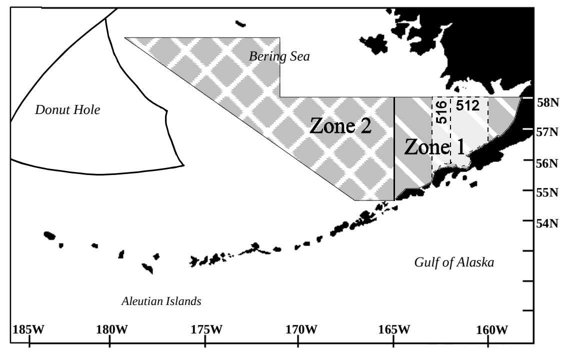
1.4.4 Bycatch Limits

The Council has adopted and NMFS has implemented numerous limits on the harvest of ecosystem components. A summary is provided below.

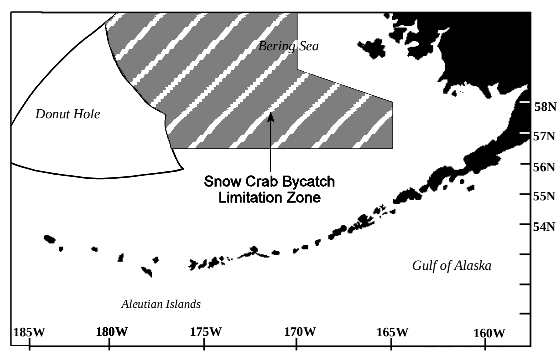
Crab - Prescribed bottom trawl fisheries in specific areas are closed when prohibited species catch (PSC) limits of *C. bairdi* Tanner crab, *C. opilio* crab, and red king crab are taken. Bycatch limitation zones for Tanner and red king crab PSC are shown in the figure below. Crab PSC limits for groundfish trawl fisheries are based on crab abundance as shown in the table below.

PSC limits for red king crab and C. bairdi Tanner crab.

Species	Zone	Crab Abundance	PSC Limit
Red King Crab	Zone 1	Below threshold or 14.5 million lbs of effective spawning biomass (EBS)	35,000
		Above threshold, but below 55 million lbs of EBS	100,000
		Above 55 million lbs of EBS	200,000
Tanner Crab	Zone 1	0-150 million crabs	0.5% of abundance
		150-270 million crabs	750,000
		270-400 million crabs	850,000
		over 400 million crabs	1,000,000
Tanner Crab	Zone 2	0-175 million crabs	1.2% of abundance
		175-290 million crabs	2,100,000
		290-400 million crabs	2,550,000
		over 400 million crabs	3,000,000



Location of the crab bycatch limitation zones.



Location of the snow crab bycatch limitation zone.

Under Amendment 40, PSC limits for snow crab (*C. opilio*) taken in groundfish fisheries will be based on total abundance of *opilio* crab as indicated by the NMFS standard trawl survey. The snow crab PSC cap is set at 0.1133% of the Bering Sea snow crab abundance index, with a minimum PSC of 4.5 million snow crab and a maximum of 13 million snow crab. Snow crab taken within the “Snow Crab Bycatch Limitation Zone”accrue towards the PSC limits established for individual trawl fisheries. Upon attainment of a snow crab PSC limit apportioned to a particular trawl target fishery, that fishery are prohibited from fishing within the snow crab zone.

Crab bycatch limits have also been established for the Alaska scallop fisheries. Annual crab bycatch limits (CBLs) are specified for red king crab and Tanner crab species in each registration area or district thereof. In Registration Area Q (the Bering Sea), the annual CBLs shall equal the following amounts:

1. The CBL of red king crab caught while conducting any fishery for scallops shall be within the range of 500 to 3,000 crab based on specific considerations.

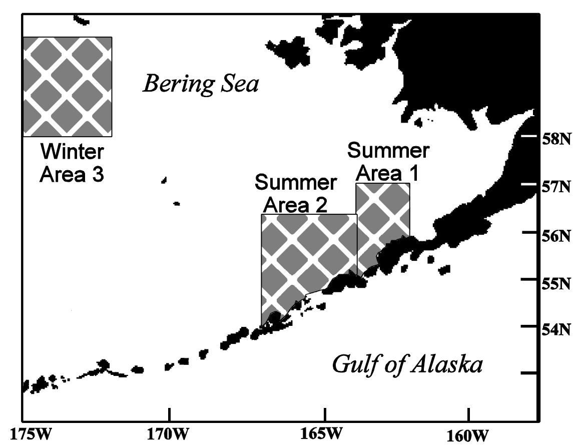
2. The CBL of *C. opilio* Tanner crab caught while conducting any fishery for scallops is 0.003176 percent of the most recent estimate of *C. opilio* abundance in Registration Area Q.
3. The CBL of *C. bairdi* Tanner crab caught while conducting any fishery for scallops is 0.13542 percent of the most recent estimate of *C. bairdi* abundance in Registration Area Q.

In other Registration Areas (Gulf of Alaska and Aleutian Islands), CBLs will be based on the biological condition of each crab species, historical bycatch rates in the scallop fishery, and other socioeconomic considerations that are consistent with the goals and objectives of the FMP.

Weathervane scallop registration areas, seasons, GHL's (pounds, shucked), and crab bycatch limits established for the 1997 scallop fishery, by area.

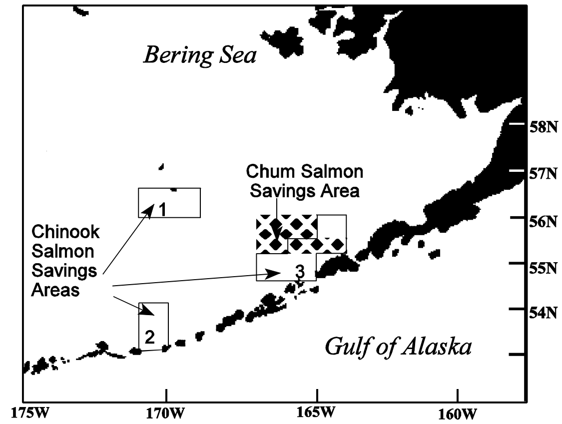
Area	GHL (pounds)	Fishing Season	Crab Bycatch Limits: king crab	Tanner crab	Snow crab
D - District 16	0 - 35,000	Jan 10 - Dec 31	n/a	n/a	n/a
D - Yakutat	0 - 250,000	Jan 10 - Dec 31	n/a	n/a	n/a
E - Eastern PWS	0 - 50,000	Jan 10 - Dec 31	n/a	500	n/a
Western PWS	combined	Jan 10 - Dec 31	n/a	130	n/a
H - Cook Inlet (Kamishak)	0 - 20,000	Aug 15 - Oct 31	60	24,992	n/a
Cook Inlet (Outer area)	combined	Jan 1 - Dec 31	98	2,170	n/a
K - Kodiak (Shelikof)	0 - 400,000	July 1 - Feb 15	35	51,000	n/a
Kodiak (Northeast)	combined	July 1 - Feb 15	50	91,600	n/a
M - AK Peninsula	0 - 200,000	July 1 - Feb 15	79	45,300	n/a
O - Dutch Harbor	0 - 170,000	July 1 - Feb 15	10	10,700	n/a
Q - Bering Sea	0 - 600,000	July 1 - Feb 15	500	238,000	172,000
R - Adak	0 - 75,000	July 1 - Feb 15	50	10,000	n/a

Pacific Halibut - Halibut bycatch limits are established in terms of total mortality. Overall bycatch mortality is limited to 4,665 mt (3,775 mt for trawl and 900 mt for non-trawl fisheries). The trawl halibut bycatch limits are apportioned to the following six fisheries in proportion to their anticipated bycatch use: (1) Yellowfin sole, (2) Rock sole/"other flatfish," (3) Turbot/arrowtooth flounder/sablefish, (4) Rockfish, (5) Pacific cod, and (6) Pollock/Atka Mackerel/"other species." Non-trawl halibut bycatch limits are primarily allocated to the Pacific cod longline fishery. Careful release requirements have been implemented in addition to bycatch limits for longline fisheries.



Pacific Herring - Herring PSC is established annually at 1% of the estimated eastern Bering sea herring biomass. The herring PSC cap is apportioned among trawl fisheries expected to take herring as bycatch. Attainment of a herring PSC apportionment will trigger trawl closures in two Herring Summer Savings Areas north of the Alaska peninsula and a Herring Winter Savings Area northwest of the Pribilof Islands to the affected fishery. These Herring Savings Areas are depicted in the adjacent figure.

Salmon - The Chum Salmon Savings Area closes to all trawling from August 1 through August 31, and remains closed if a bycatch limit of 42,000 chum salmon is taken in the catcher vessel operational area (CVOA). Trawling is prohibited in the Chinook Salmon Savings Areas upon attainment of a bycatch limit of 48,000 chinook salmon in the BSAI. These areas are shown in the adjacent figure.



1.4.5 Gear Restrictions

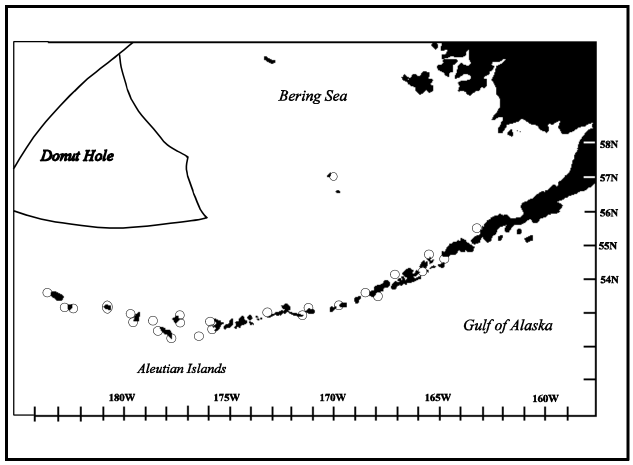
In the Alaska weathervane scallop fishery, dredge size is limited to a maximum width of 15 feet, and only 2 dredges may be used at any one time. In the Kamishak District of Cook Inlet, only 1 dredge with a 6' maximum width is allowed. Dredges are required to have rings with a 4" minimum inside diameter to reduce the catch of small, immature scallops.

In the BSAI king and Tanner crab pot fisheries, pot size is limited to a maximum of 10 foot by 10 foot. Pots used in the crab and groundfish fisheries are required to have biodegradable panels. Additionally, pots used in groundfish fisheries must have rigid tunnel opening that are not larger than 9 inches by 9 inches, to reduce bycatch of halibut. Pots used in Tanner crab fisheries are required to have smaller openings to exclude king crab. Escape rings or a large mesh panel are also required in crab pots.

There are no gear restrictions for trawl fisheries or longline fisheries at this time. However, the Council at its June 1998 meeting approved an amendment which will be submitted for Secretarial review to prohibit the use of nonpelagic trawls in the BSAI directed pollock fishery.

1.4.6 Measures to Reduce Interactions with Marine Mammals

To protect walrus, fishing vessels are prohibited in that part of the Bering Sea within twelve miles of Round Island, the Twins and Cape Pierce in northern Bristol Bay during the period April 1 through September 30. To protect Steller sea lions, no trawling is allowed year round in the BSAI within 10 nautical miles of 27 Steller sea lion rookeries. In addition, six of these rookeries will have 20 nautical mile trawl closures during the pollock "A" season. These closures revert back to 10 nautical miles when the "A" season is over, either on or before April 15. There are additional rookery closures in the GOA.



Location of the no trawl zones around Steller sea lion rookeries in the Bering Sea and Aleutian Islands area.

Several other management measures have been incorporated marine mammal concerns. The two million mt OY cap restricts the BSAI catch of groundfish to much less than could be taken based on acceptable biological rates for individual species. This leaves more fish for marine mammals and other predators, as well as decomposers and other components of the Bering Sea and Aleutian Islands ecosystems. An ending date of November 1 for the pollock "B" season was instituted explicitly to prevent pollock fisheries from becoming temporally compressed in the winter months, to decrease the chance of localized depletion of prey for Steller sea lions. The TAC for Atka mackerel in the Aleutian Islands is allocated among subareas to spatially disperse fishing effort to decrease the chance of localized depletion of this prey species. Amendment 36/39 prohibits commercial exploitation of forage fish species such as capelin, sand lance, and smelt, which are eaten by various marine mammals and seabirds.

1.5 Evaluation of Current Management Measures to Protect EFH in Alaska

This section of the analysis assesses the relative impacts of fishing equipment used in waters described as EFH. A review of existing fishery management measures as they relate to protection of EFH was provided in Section 1.4.

Area closure to trawling and dredging in the BSAI and GOA serve to protect habitat from potential adverse impacts caused by these gear types. A summary evaluation of each is provided below:

- The nearshore Bristol Bay Closure Area encompasses 19,000 square nautical miles. This area contains rare habitat types (bryozoans and other living substrates), it is important ecologically (absolutely critical for young-of-the-year red king crab survival), and it is vulnerable and highly sensitive to fishing gear damage.
- The Pribilof Islands Habitat Conservation Area encompasses 7,000 square nautical miles. This area contains rare habitat types (shell hash), it is important ecologically (needed for juvenile blue king crab survival), and it is vulnerable to bottom trawl gear damage via crushing, burying, and siltation. Other gear types probably do not have a significant impact on this habitat.
- The Red King Crab Savings Area covers 4,000 square nautical miles. This area contains a known concentration of adult red king crab. Its primarily sand/silt substrate does not appear as sensitive to the impacts of fishing gear as some other types of substrate.
- The closure areas around Kodiak Island and along the Alaska Peninsula were designed to reduce bycatch and other impacts of trawl and dredge gear on red king crab. This area may contain concentrations of juvenile red king crab.

Other management measures were designed to reduce the impact of fishing on marine ecosystems. Catch quotas, bycatch limits, and gear restrictions control removals of prey species. Area closures around marine mammal rookeries and haulouts reduce fishery interactions with these predators.

The Council approved a permanent closure of a four-mile square area around the Cape Edgecumbe pinnacles near Sitka at its June 1998 meeting; the regulation implementing this closure is under development. The action would close the area to boat anchoring and to fishing for groundfish, halibut and scallops; commercial and recreational fishing for salmon would be allowed. The pinnacles area is extremely productive; it provides habitat for spawning, breeding, feeding, growth, and growth to maturity for a variety of species.

The need for additional protective measures outside of the current management regime (and excluding the Cape Edgecumbe pinnacle closure) was not demonstrated from a review of the best scientific information available during development of the EFH amendment package. The measures outlined in Section 1.4 demonstrate that the Council and the Secretary of Commerce have taken appropriate actions when threats to fish habitat have been identified. At this time, the need for other protective measures was not demonstrated from a review of the best scientific information available during the development of the EFH FMP. These conclusions considered whether, and to what extent, fishing activities are adversely impacting EFH; the nature and extent of adverse effects on EFH; and whether the management measures are practicable, taking into consideration the long-and short-term costs as well as benefits to the fishery and its EFH, consistent with national standard 7.

In the future, additional management measures may be proposed as new information (biological, economic, or other appropriate factors) becomes available. Proposals to amend FMPs to minimize potential adverse effects from fishing can be submitted during the Council's plan amendment cycle. Proposals can be made by anyone, such as fishermen, industry groups, conservation groups, general public, plan teams, or even the Council itself.

The amendment cycle is as follows:

1. A call for proposals is issued in June, with proposals due in mid-August.
2. The plan teams review proposals in September and provide the Council with guidance.
3. The Council and its advisory bodies review proposals in October and determine which ones should be further developed for analysis.
4. Analysis (Environmental Assessment and Regulatory Impact Review or Environmental Impact Statement) is completed for initial review at the following April meeting.
5. The Council takes final action on the amendment at its June meeting and forwards the amendment package thereafter to the Secretary of Commerce for approval.

The NMFS interim final rule guidelines on EFH specify that the Councils and NMFS should periodically review the EFH components of FMPs, including an update of the fishing gear impacts assessment. Each EFH FMP amendment should include a provision requiring review and update of EFH information and preparation of a revised FMP amendment if new information becomes available. The schedule for this review should be based on an assessment of both the existing data and expectations of when new data will become available. This information should be reviewed as part of the annual Stock Assessment and Fishery Evaluation (SAFE) report. A complete review of information should be conducted as recommended by the Secretary, but at least once every five years.

1.6 Status of Fishery Resources in the Alaska Region

Definitions of EFH can depend on the status of the fish stock. The interim final rule provides some guidelines on defining EFH based on status of the stock. Three levels of stock abundance are considered, as follows:

1. Overfished stocks: *If a species is overfished, and habitat loss or degradation may be contributing to the species being identified as overfished, all habitats currently used by the species should be considered essential in addition to certain historic habitats that are necessary to support rebuilding the fishery and for which restoration is technologically and economically feasible. Once the fishery is no longer considered overfished, the EFH identification should be reviewed, and the FMP amended, if appropriate.*

2. Threatened or Endangered stocks: *EFH will always be greater than or equal to aquatic areas that have been identified as "critical habitat" for any managed species listed as threatened or endangered under the Endangered Species Act.*

3. Healthy stocks: *Where a stock of a species is considered to be healthy, then EFH for the species should be a subset of all existing habitat for the species*.

No species off Alaska is currently known to be overfished of listed as threatened or endangered under ESA. For 42 rockfish species of very minor commercial and recreational importance (many listed are not harvested at all), the status is unknown, but the remainder are considered healthy (NMFS "Report to Congress on the Status of Fisheries of the United States, 1998). One stock of BSAI groundfish (Bogoslof pollock) and one BSAI crab species (Tanner crab) may be deemed overfished in the future based on preliminary analysis currently being conducted to address National Standard 1 guidelines. There are several northwest stocks of Pacific salmon listed under ESA that utilize the Alaska EEZ to some extent during their juvenile life stage. None of these listed stocks originate in Alaska.

The best available scientific information on the status of stocks is found in the annual Stock Assessment and Fishery Evaluation (SAFE) documents prepared annually for the groundfish, crab, and scallop FMPs. Copies of the SAFE documents are available from the Council office.

2.0 NEPA REQUIREMENTS: ENVIRONMENTAL IMPACTS OF THE ALTERNATIVES

An environmental assessment (EA) is required by the National Environmental Policy Act of 1969 (NEPA) to determine whether the action considered will result in significant impacts on the human environment. If the action is determined not to be significant based on an analysis of relevant considerations, the EA and resulting finding of no significant impact (FONSI) would be the final environmental documents required by NEPA. An environmental impact statement (EIS) must be prepared for major Federal actions significantly affecting the human environment. A final supplemental EIS for the Alaska groundfish fisheries, dated December 1998, was approved by NMFS and the Notice of Availability was published December 24, 1998.
(63 FR 71285).

An EA must include a brief discussion of the need for the proposal, the alternatives considered, the environmental impacts of the proposed action and the alternatives, and a list of document preparers. The purpose and alternatives were discussed in Sections 1.1 and 1.2, and the list of preparers is in Section 5. The following section contains the discussion of the environmental impacts of the alternatives, including impacts on threatened and endangered species and marine mammals.

2.1 Environmental Impacts of the Alternatives to Describe and Identify EFH

The environmental impacts generally associated with fishery management actions include: (1) changes in availability of food to predators and scavengers, changes in the population structure of target fish stocks, and changes in the marine ecosystem community structure resulting from harvest of fish stocks; (2) changes in the physical and biological structure of the marine environment as a result of fishing practices (e.g. using certain kinds of gear, discarding fish processing waste); and (3) entanglement/entrapment of non-target organisms in active or inactive fishing gear.

2.1.1 Physical Environment

The areas identified as EFH will be a subset of the habitat currently or historically used by fish managed under the Magnuson-Stevens Act. Because of the large variability in the fish species managed under the Magnuson-Stevens Act, the areas identified as EFH will encompass a wide range of aquatic habitats. These include streams and rivers supporting anadromous fish species; marine and estuarine habitat types such as seagrass beds, coral reefs, tidal marshes, coastal wetlands, submerged aquatic vegetation, cobble with attached fauna, dense mud and clay burrows; and oceanic banks and continental shelf or slope areas extending to the 200-mile EEZ. Aquatic areas that do not currently support fish, but that have historically done so, and that could support fish if restored, may also be identified as EFH. The environment directly affected by the plan amendments are likely to be primarily marine and estuarine habitats. Some of the species managed under the Magnuson-Stevens Act are anadromous fish, such as salmon, which spend most of their lives in the marine environment, but migrate to fresh water streams for spawning. For these species, it is likely that EFH will be identified in some fresh water streams in coastal and inland states.

In the case of riverain habitat, which is particularly important to anadromous fish, habitat loss has resulted from loss of access for fish, water pollution, inadequate flow, and physical destruction of habitat. The Pacific coast has well-known examples of fisheries resources damaged by loss of access to habitat and degradation of available habitat.

Activities which have been determined to have an adverse impact on EFH may be redirected to other areas such as uplands or aquatic areas not identified as EFH. Through this process, a regulation could indirectly affect almost any part of the coastal watershed of the United States, although the areas most likely to be affected by redirected activities are coastal areas where activities likely to adversely affect EFH occur.

2.1.2 Effects on Fish Habitat

The goal of the definition and identification of EFH is to improve conservation and management recommendations to Federal agencies, state agencies, and other entities whose actions may adversely affect EFH. The achievement of this goal will depend on individual decisions made by these bodies. It is not possible to predict the nature of those future decisions for specific sites. Therefore, the consequences of the alternatives can only be addressed in a general sense.

The synthesis and publication of information on EFH and EFH conservation recommendations provided by NMFS or the Councils should strongly encourage avoidance of activities that may adversely affect fish habitat in these areas. For example, development projects that may adversely impact EFH may be set back further from the coast and may be required to provide vegetated buffers or alternate methods to treat surface runoff. EFH conservation recommendations may advise the use of environmentally sound engineering and management practices (e.g., seasonal restrictions, specific dredging methods, and disposal options) for all dredging and construction projects. EFH conservation recommendations may suggest the restoration of riparian and coastal areas through re-establishing endemic trees and other plants, and restoring natural bottom characteristics. Upland restoration measures such as erosion control, road stabilization, upgrading culverts, or modification of the operating procedures of dikes or levees to allow fish passage may be recommended as necessary to protect EFH. EFH conservation recommendations may also advise against alteration of the natural hydrology of rivers and estuaries, except to restore degraded habitat. If implemented by the action agencies, EFH conservation recommendations provided by a Council or NMFS will improve the conservation of important aquatic habitats and the associated ecosystem.

Council FMP amendments to protect EFH may exclude fishing techniques that may cause physical disturbance of the substrate, loss of and/or injury to benthic organisms, loss of prey species and/or their habitat, and changes to other components of the ecosystem. These amendments may also establish research closure areas to evaluate the impact of any fishing activities on EFH or establish marine reserves to protect certain habitat from adverse fishing impacts. All of the actions will have a beneficial effect on fish habitat and the associated ecosystems.

Preferred Alternative 2 is the most conservative program for protecting essential fish habitat. Designation of general distribution for species life stages with level 2 and higher information as EFH will trigger more consultations with NMFS on proposed actions that may adversely impact EFH. Alternative 3 would tend to trigger fewer consultations, as somewhat smaller areas would be designated as EFH.

2.1.3 Effects on Fish Populations

The EFH requirements were included in the Magnuson-Stevens Act because scientific evidence indicates that habitat loss or degradation has compounded, and in some cases magnified, the effects of increased fishing pressures. The net effect has been a decline in many of the nation's important fish stocks. Protection from further adverse impacts and restoration of degraded EFH, where feasible, should reduce some of the stress on populations, and fishery stocks should stabilize or regain some lost productivity. Evidence from boreal, temperate, and tropical regions of the world support the theory that if habitat degradation is halted or minimized, and biological integrity is restored, associated fish populations will increase both inside the protected areas and outside. This prediction is supported by more than 250 peer-reviewed articles on recovery dynamics of marine fishery reserves (areas protected from further impacts) in studies around the world. Additional benefits that would be expected from adequate levels of habitat protection include: the restoration of the population age (or size) structure, conservation of genetic diversity in the population, development or maintenance of greater diversity in trophic structure and greater assurance of the availability of alternate trophic pathways; increased resilience for the populations to withstand both natural and anthropogenic stresses; and greater stability in both the populations or assemblages and the fishery catch.

All of the options and alternatives to the status quo would be expected to reduce some of the stress on populations, and fishery stocks should benefit in terms of long-term productivity.

2.1.4 Other Environmental Effects

The implementation of either Alternative 2 or 3 should not produce any unavoidable adverse environmental impacts. Designation of EFH is intended to protect the environment by controlling adverse physical and biological impacts on the habitat of living marine resources. Once EFH is designated, Federal agencies must consult with NMFS regarding any of their actions that may adversely affect EFH. Agencies may require changes in activities which result in degradation of coastal waters and habitats. These changes, such as directing that dredged material disposal occur away from critical coastal areas, or that disturbance to spawning areas be restricted to non-spawning seasons, would not result in any unavoidable adverse environmental impacts.

The overall purpose of these EFH designations is to conserve, protect, and restore coastal waters, and thus to enhance the long-term health of all living marine resources. These alternatives will not cause any short- term uses of the environment that would reduce long-term productivity. Short-term uses of the environment may have to be modified because of measures which result from EFH conservation recommendations or fishery management measures. The most likely consequence to non-fishing activities would be the modification or relocation of a Federally permitted activity if scientific evidence suggests that the activity would adversely affect designated EFH. For example, This may result in short-term costs to the users, but will result in long-term benefits to the economy and environment.

The alternatives analyzed in this EA will not cause any irreversible or irretrievable commitment of resources as a result of their implementation. Definitions of EFH have been proposed in this analysis, but may be revised in the future as new information becomes available.

2.2 Socioeconomic Impacts of the Alternatives

The action proposed in these alternatives is simply to describe and identify EFH for FMP species, which in and of itself will have no economic impact.

Future regulations arising from this action may have an impact on fisheries participants. The most likely short-term consequence to commercial and recreational fishermen would be the need to relocate their fishing or change their methods. If scientific evidence suggests that particular fishing gear types or methods are adversely affecting the habitat necessary to a managed species in one or more of its life stages, then seasonal, annual or permanent restrictions to minimize those impacts could be proposed. In that case, fishermen who have traditionally used the restricted area may need to increase their search or travel distance to find other suitable fishing grounds, or may need to invest in equipment more appropriate for use in the identified EFH. It is possible that restrictions will be imposed such that some fishermen will be unable to relocate or acquire new gear.

Overall, any short-term economic losses should be compensated by future increases in catch levels and increased stability in the fishery. The long-term expectation of the Magnuson-Stevens Act's EFH mandate is that declining trends in fish stocks can be halted or reversed by minimizing adverse impacts to EFH, and by restoring lost habitat or access to habitat, where feasible (in addition to management measures directed at harvest). Protecting the quality and quantity of EFH should increase the survival potential of managed fishery species, and increase the biological productivity of the ecosystem, including the stocks of managed species within that ecosystem. Increases in stock abundance and fish sizes should result in stabilization of interannual variations in catch, and increased economic return. Both alternatives to the status quo would be expected to provide long-term gains for Alaska fisheries.

This remainder of this section provides information about the fishing fleet which might be affected by future regulations related to the EFH amendments, as well as administrative, enforcement and information costs of the alternatives.

2.2.1 Alaska fishing fleet

The following tables present data summarizing the number of vessels by gear and area that harvested Alaska groundfish in the BSAI and GOA in 1996, scallops in Alaska, and crab in the BSAI.

The total number of fishing vessels was estimated based on the number of vessels that made landings in 1996. The number of catcher vessels by category was estimated using information published by NMFS for the 1996 groundfish fisheries (NMFS, 1997 - the "Economic SAFE", Table 25). The number of catcher/processors, motherships, floating processors and shoreside processors was estimated based on the number of processors submitting Weekly Production Reports for groundfish fisheries to NMFS in 1996.

Number of vessels that caught groundfish in the BSAI area in 1996, by vessel length class (measured by length overall (LOA) in feet), catcher type, and gear.

	<60'	60-124'	>125'	Total
Catcher vessels				
Fixed gear	64	125	17	206
Trawl gear	6	91	31	128
Catcher/processors				
Fixed gear	1	21	32	54
Trawl gear	0	7	55	62
Total all vessels	71	244	135	450

Number of vessels that caught groundfish in the GOA area in 1996, by vessel length class (measured by length overall (LOA) in feet), catcher type, and gear.

	<60'	60-124'	>125'	Total
Catcher vessels				
Fixed gear	1116	179	7	1302
Trawl gear	63	82	17	162
Catcher/processors				
Fixed gear	4	13	11	28
Trawl gear	0	7	30	37
Total all vessels	1183	281	65	1529

Number of vessels that landed scallops in Alaska in 1996 and 1997, by vessel length class (measured by length overall (LOA) in feet).

	<60'	60-124'	>125'	Total
Cook Inlet				
1996	0	4	0	4
1997	1	2	0	3
Outside Cook Inlet				
1996	0	4	0	4
1997	0	6	0	6

Number of vessels that caught crab in the BSAI area in 1996, by vessel length class (measured by length overall (LOA) in feet), catcher type, and gear.

	Catcher vessels			Catcher/
	<60'	60-124'	>125'	proc.s
Bristol Bay red king	0	130	62	4
Bering Sea Tanner	0	102	40	4
Bering Sea Snow crab	0	154	70	15
Norton Sound red king	41	0	0	0

Many vessels overlap, fishing both in the BSAI and the GOA. The estimated total number of participants in the BSAI and GOA groundfish fisheries is 1,686 (NMFS, 1997 - the "Economic SAFE", Table 23). An additional 3,532 commercial fishing permits were issued for the 1996 salmon fishery in southeast Alaska (164 set gillnet, 483 drift gillnet, 417 purse seine, 1,513 hand troll, 955 power troll permits). Therefore, the total universe of participants is estimated at 5,218.

2.2.2 Administrative, Enforcement and Information Costs

The proposed EFH amendment would require NMFS to implement three new functions:

1. Development and management of a EFH cumulative impacts information system which includes coordination with various Federal and State agencies.

2. Development of an EFH consultation system which includes coordination with various Federal and State agencies.

3. Review and update EFH assessments as new information becomes available, or at least once every five years.

2.2.3 Summary Findings of Economic Impacts

None of the alternatives would have an economic impact on participants in the Alaska fisheries or on other business entities, since the action proposed in these plan amendments is simply to define EFH for FMP species. However, the Alaska fishery fleet that could be affected by future regulations arising from this action are identified above.

While this specific action would not have economic impacts, it could form the basis for future actions, either regulatory measures that restrict fishing practices or recommendations to other Federal or State agencies that suggest modification of an action to protect or enhance EFH, that could have negative short-term economic impacts. Designation of EFH would result in somewhat smaller areas under Alternative 3 than under Alternative 2. The slightly larger area identified by Alternative 2 may trigger more consultations with other Federal and State agencies on proposed actions that could adversely affect designated EFH. Recommendations that result from these consultations could suggest modifications to the proposed action that could result in increased economic costs. However, the EFH consultation process does not require the Federal or State action agency to implement the recommendations. Additionally, the slightly larger area identified by Alternative 2 may trigger the need for increased fishing regulations if fishing practices in the larger area adversely affect EFH found within that area. It is anticipated that any short-term negative economic impacts that result from future regulations or recommendations are offset by the long-term impacts that would result from the protection and enhancement of EFH.

2.3 Consequences of the Alternatives

The consequences of the No Action Alternative are that a program for the conservation and management of EFH in Alaska would not be implemented. Agency decision-makers would not be able to avail themselves of information on the importance of certain habitats to marine fisheries, and their decisions regarding actions that could adversely affect EFH might not give adequate consideration to the need for conservation of particular habitats. Fish populations may remain threatened by habitat loss, and additional fish populations would most likely become threatened as habitat loss continued. Commercial and recreational fishers dependent on declining fisheries would continue to experience lost revenues and increased uncertainty. Furthermore, the Magnuson-Stevens Act requires that FMPs be amended to identify and describe EFH; failure to amend the FMPs to include EFH would place NMFS in non-compliance with a statutory requirement.

All of the options and alternatives to the status quo would be expected to benefit marine and anadromous fish populations, and provide for improved long-term productivity of the fisheries.

Alternative 2 is the most conservative alternative simply because a larger area is designated EFH for species life stage with level 2 or higher information. The larger area identified by Alternative 2 may trigger more consultations on proposed actions that could adversely affect EFH. Additionally, the slightly larger area identified by Alternative 2 may trigger the need for more fishing regulation if fishing practices within an area not included as EFH under Alternative 3 adversely affect EFH found within that area. With regards to fish production, Alternative 2 is also more likely to ensure long-term productivity of a stock because designation of the larger area would include all habitats occupied by a species that contribute to production at some level and are therefore necessary to maintain sustainable fisheries and contribute to a healthy ecosystem. As stated in the NMFS EFH Technical Guidelines, "When considering EFH requirements of a managed species, Councils must describe, identify, and conserve enough habitat to support the total population (biological production), not just the individual fish that are removed by fishing (the fisheries production). If the current stock size supports the long-term potential yield of the fishery, then EFH should be adequate to support that population and its contribution to a healthy ecosystem." Simply stated, Alternative 2 is a more precautionary approach to EFH designation than Alternative 3.

Alternative 3 differs from Alternative 2 in that EFH would be defined as a subset of all habitat within a general distribution [e.g., areas of known concentration] in the case of level 2 information or greater for a species life stage for stocks deemed to be in healthy condition. For level 0 and 1 information, EFH would be defined as all habitat within a general distribution for a species life stage. Therefore, under Alternative 3, designation of EFH would result in somewhat smaller areas (areas of known concentration versus general distribution) for those species with level 2 information or greater for a species life stage. Areas of known concentrations are based on current information that does not adequately address unpredictable annual differences in spatial distributions of a life stage, nor changes due to long-term shifts in oceanographic regimes. Identified known concentrations are based primarily on survey information, which is limited to certain seasons (chiefly summer). Furthermore, to define EFH as known concentrations may omit important habitats occupied by a species and that are necessary to maintain healthy stocks within the ecosystem. Section 6.0 contains further information and examples on the differences between Alternatives 2 and 3.

2.4 Impacts on Endangered or Threatened Species

The ESA provides for the conservation of endangered and threatened species of fish, wildlife, and plants. The program is administered jointly by the Department of Commerce (NMFS) for most marine species, and the Department of Interior (USFWS) for terrestrial and freshwater species.

The ESA procedure for identifying or listing imperiled species involves a two-tiered process, classifying species as either threatened or endangered, based on the biological health of a species. Threatened species are those likely to become endangered in the foreseeable future [16 U.S.C. §1532(20)].

Endangered species are those in danger of becoming extinct throughout all or a significant portion of their range [16 U.S.C. §1532(20)]. The Secretary, acting through NMFS, is authorized to list marine mammal and fish species. The Secretary of Interior, acting through the USFWS, is authorized to list all other organisms.

In addition to listing species under the ESA, the critical habitat of a newly listed species must be designated concurrent with its listing to the "maximum extent prudent and determinable" [16 U.S.C. §1533(b)(1)(A)]. The ESA defines critical habitat as those specific areas that are essential to the conservation of a listed species and that may be in need of special consideration. The primary benefit of critical habitat designation is that it informs Federal agencies that listed species are dependent upon these areas for their continued existence, and that consultation with NMFS on any Federal action that may affect these areas is required. Some species, primarily the cetaceans, listed in 1969 under the Endangered Species Conservation Act and carried forward as endangered under the ESA, have not received critical habitat designations.

Listed Species. The following species are currently listed as endangered or threatened under the ESA and occur in the GOA and/or BSAI:

Endangered

Northern Right Whale	*Balaena glacialis*
Bowhead Whale[1]	*Balaena mysticetus*
Sei Whale	*Balaenoptera borealis*
Blue Whale	*Balaenoptera musculus*
Fin Whale	*Balaenoptera physalus*
Humpback Whale	*Megaptera novaeangliae*
Sperm Whale	*Physeter macrocephalus*
Snake River Sockeye Salmon	*Oncorhynchus nerka*
Short-tailed Albatross	*Diomedia albatrus*
Steller Sea Lion[2]	*Eumetopias jubatus*

Threatened

Snake River Fall Chinook Salmon	*Oncorhynchus tshawytscha*
Snake River Spring/Summer Chinook Salmon	*Oncorhynchus tshawytscha*
Steller Sea Lion[3]	*Eumetopias jubatus*
Spectacled Eider	*Somateria fishcheri*
Steller's Eider	*Polysticta stelleri*

Section 7 Consultations. Because scallop, BSAI crab, salmon, and groundfish fisheries are federally

[1]species is present in Bering Sea area only.

[2]listed as endangered in waters west of Cape Suckling.

[3]listed as threatened in waters east of Cape Suckling.

regulated activities, any negative affects of the fisheries on listed species or critical habitat and any takings[4] that may occur are subject to ESA section 7 consultation. NMFS initiates the consultation and the resulting biological opinions are issued to NMFS. The Council may be invited to participate in the compilation, review, and analysis of data used in the consultations. The determination of whether the action "is likely to jeopardize the continued existence of" endangered or threatened species or to result in the destruction or modification of critical habitat, however, is the responsibility of the appropriate agency (NMFS or USFWS). If the action is determined to result in jeopardy, the opinion includes reasonable and prudent measures that are necessary to alter the action so that jeopardy is avoided. If an incidental take of a listed species is expected to occur under normal promulgation of the action, an incidental take statement is appended to the biological opinion.

Section 7 consultations have been done for all the above listed species, some individually and some as groups. Below are summaries of the consultations.

Endangered Cetaceans. NMFS concluded a formal section 7 consultation on the effects of the BSAI and GOA groundfish fisheries on endangered cetaceans within the BSAI and GOA on December 14, 1979, and April 19, 1991, respectively. These opinions concluded that the fisheries are unlikely to jeopardize the continued existence or recovery of endangered whales. Consideration of the bowhead whale as one of the listed species present within the area of the Bering Sea fishery was not recognized in the 1979 opinion, however, its range and status are not known to have changed. No new information exists that would cause NMFS to alter the conclusion of the 1979 or 1991 opinions. Of note, however, are observations of Northern Right Whales during Bering Sea stock assessment cruises in the summer of 1997 (NMFS per. com). Prior to these sightings, and one observation of a group of two whales in 1996, confirmed sightings had not occurred.

Steller sea lion. The Steller sea lion range extends from California and associated waters to Alaska, including the Gulf of Alaska and Aleutian Islands, and into the Bering Sea and North Pacific and into Russian waters and territory. In 1997, based on biological information collected since the species was listed as threatened in 1990 (60 FR 51968), NMFS reclassified Steller sea lions as two distinct population segments under the ESA (62 FR 24345). The Steller sea lion population segment west of 144°W. longitude (a line near Cape Suckling, Alaska) is listed as endangered; the remainder of the U.S. Steller sea lion population maintains the threatened listing.

NMFS designated critical habitat in 1993 (58 FR 45278) for the Steller sea lion based on the Recovery Team's determination of habitat sites essential to reproduction, rest, refuge, and feeding. Listed critical habitats in Alaska include all rookeries, major haul-outs, and specific aquatic foraging habitats of the BSAI and GOA. The designation does not place any additional restrictions on human activities within designated areas. No changes in critical habitat designation were made as result of the 1997 re-listing.

Beginning in 1990 when Steller sea lions were first listed under the ESA, NMFS determined that both groundfish fisheries may adversely affect Steller sea lions, and therefore conducted Section 7 consultation on the overall fisheries (NMFS 1991), and subsequent changes in the fisheries (NMFS 1992). On January 26, 1996, two biological opinions on the BSAI and GOA fisheries' effects on Steller sea lions were issued by NMFS. Both concluded that these fisheries and the 1996 harvest levels were not likely to jeopardize the continued existence and recovery of the Steller sea lion, nor to result in the destruction or adverse modification of critical habitat. NMFS supplemented the biological opinions for

[4] the term "take" under the ESA means "harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or attempt to engage in any such conduct" (16 U.S.C. §1538(a)(1)(B).

the 1998 Atka mackerel fishery in the BSAI and GOA pollock fishery with potential impacts of those fisheries on Steller sea lions.

On February 26, 1998, NMFS determined that the 1996 biological opinion on the effects of the BSAI groundfish fishery on Steller sea lions remained valid for the 1998 BSAI groundfish fishery. On March 2, 1998, NMFS issued a biological opinion concluding that the 1998 GOA groundfish fishery was not likely to jeopardize the continued existence and recovery of Steller sea lions, nor to adversely modify critical habitat. NMFS noted that the biological opinion only addressed the 1998 fishery, not the continued implementation of the GOA FMP beyond 1998. On August 20, 1998, NMFS reinitiated section 7 consultation on: (1) authorization of an Atka mackerel fishery under the BSAI groundfish FMP between 1999 and 2002; (2) authorization of a pollock fishery under the BSAI groundfish FMP between 1999 and 2002; and (3) authorization of a pollock fishery under the GOA groundfish FMP between 1999 and 2002. A biological opinion dated December 3, 1998, modified December 16, 1998, was issued for authorization of Atka mackerel and walleye pollock fisheries in the BSAI and walleye pollock fisheries in the GOA , which concluded that the pollock fisheries in the BSAI and GOA are likely to jeopardize the continued existence of the Steller sea lion. A biological opinion dated December 22, 1998, was issued for authorization of the BSAI and GOA groundfish fisheries based on total allowable catch specifications for 1999, which concluded that the proposed groundfish fisheries are not likely to jeopardize the Steller sea lion.

Pacific Salmon. No species of Pacific salmon originating from freshwater habitat in Alaska are listed under the ESA. Those species that are listed originate in freshwater habitat in the headwaters of the Columbia (Snake) River. During ocean migration to the Pacific marine waters a small (undetermined) portion of the stock go into the Gulf of Alaska as far east as the Aleutian Islands. In that habitat they are mixed with hundreds to thousands of other stocks originating in the Columbia River, British Columbia, Alaska, and Asia. The listed fish are not visually distinguishable from the other, unlisted, stocks. Mortal take of them in the chinook salmon bycatch portion of the fisheries is assumed based on sketchy abundance, timing, and migration pattern information.

NMFS designated critical habitat in 1992 (57 FR 57051) for the for the Snake River sockeye, Snake River spring/summer chinook, and Snake River fall chinook salmon. The designations did not include any marine waters, and therefore does not include any of the habitat where the groundfish fisheries are promulgated.

NMFS has issued two biological opinions and no-jeopardy determinations for listed Pacific salmon in the Alaska groundfish fisheries (NMFS 1994, NMFS 1995). Conservation measures were recommended to improve the level of information about and reduce salmon bycatch. The no jeopardy determination was based on the assumption that if total salmon bycatch is controlled, the impacts to listed salmon are also controlled. The incidental take statement appended to the second biological opinion allowed for take of one Snake River fall chinook and zero take of either Snake River spring/summer chinook or Snake River sockeye, per year. As explained above, it is not technically possible to know if any have been taken. Compliance with the biological opinion is stated in terms of limiting salmon bycatch per year to under 55,000 and 40,000 for chinook salmon, and 200 and 100 sockeye salmon in the BSAI and GOA fisheries, respectively.

NMFS has issued six biological opinions and no-jeopardy determinations for listed Pacific salmon in the Southeast Alaska Salmon Troll fishery (NMFS 1993; 1994; 1995; 1996; 1997; 1998). Conservation measures contained in these past opinions have varied somewhat, but generally have been recommendations limiting chinook harvest in the commercial all-gear fishery consistent with US/Canada treaty negotiations. Each of the first five biological opinions contained one-year expiration dates, but the June 29, 1998 opinion will remain in effect as long as the 1996 U.S. Letter of Agreement regarding Chinook Salmon Fisheries in Alaska remains in place, or until a bilateral agreement between the U.S. and Canada regarding the management of chinook fisheries under PSC jurisdiction is proposed.

Additional evolutionarily significant units (ESUs) of Pacific salmon are currently in the process of being listed under the ESA. Depending on the final listing decisions, additional Section 7 consultations or Section 10 incidental take permits will be required for salmon fisheries in waters off Alaska.

Short-tailed albatross. The entire world population in 1995 was estimated as 800 birds; 350 adults breed on two small islands near Japan. The population is growing but is still critically endangered because of its small size and restricted breeding range. Past observations indicate that older short-tailed albatrosses are present in Alaska primarily during the summer and fall months along the shelf break from the Alaska Peninsula to the Gulf of Alaska, although 1- and 2-year old juveniles may be present at other times of the year (USFWS 1993). Consequently, these albatrosses generally would be exposed to fishery interactions most often during the summer and fall--during the latter part of the second and the whole of the third fishing quarters.

Short-tailed albatrosses reported caught in the longline fishery include two in 1995, one in September 1996, and none in 1997. Both 1995 birds were caught in the vicinity of Unimak Pass and were taken outside the observers' statistical samples.

Formal consultation on the effects of the groundfish fisheries on the short-tailed albatross under the jurisdiction of the U.S. Fish and Wildlife Service (USFWS) concluded that BSAI and GOA groundfish fisheries would adversely affect the short-tailed albatross and would result in the incidental take of up to two birds per year, but would not jeopardize the continued existence of that species (USFWS 1989). Subsequent consultations for changes to the fishery that might affect the short-tailed albatross also concluded no jeopardy (USFWS 1995, USFWS 1997). The USFWS does not intend to renew consultation for the 1998 Total Allowable Catch specification process. However, the incidental take limit established in the 1997 USFWS biological opinion is valid for 1997, 1998, and extended into 1999. However, NMFS must reinitiate consultation for the 1999 groundfish hook-and-line fisheries.

Spectacled Eider. These sea ducks feed on benthic mollusks and crustaceans taken in shallow marine waters or on pelagic crustaceans. The marine range for spectacled eider is not known, although Dau and Kitchinski (1977) review evidence that they winter near the pack ice in the northern Bering Sea. Spectacled eider are rarely seen in U.S. waters except in August through September when they molt in northeast Norton Sound and in migration near St. Lawrence Island. Recent satellite telemetry data and three years of ate winter aerial surveys indicate that spectacled eiders spend the winter in exposed waters between St. Matthew and St. Lawrence Islands, or in open leads slightly west of the inter-island area (USFWS 1998c). Although the species is noted as occurring in the GOA and BSAI management areas no evidence that they interact with these groundfish fisheries exists.

Steller's Eider. The Alaska breeding population of the Steller's eider was listed as threatened in 1997. These are sea ducks that spend the majority of the year in shallow, nearshore marine waters where they feed by diving and dabbling for molluscs and crustaceans. Principle foods in the marine areas include bivalves, crustaceans, polychaete worms, and molluscs (Metzner 1993, Petersen 1980, Troy and Johnson 1987). During the breeding season, Steller's eiders move inland in coastal areas, where they nest adjacent to shallow ponds or within drained lake basins (Flint et al. 1984, King and Dau 1981, Quakenbush and Cochrane1993). Although they are noted as occurring in the GOA and BSAI management areas, no evidence exists that they interact with the groundfish fisheries or compete with the target species for prey.

As noted previously in the discussion of the short-tailed albatross, from 1992 to 1994 NMFS initiated informal consultations with USFWS on the annual TAC specifications for the BSAI and GOA. USFWS concurred that the proposed actions would not jeopardize the continued existence of any listed species under its jurisdiction beyond those already considered in the 1989 biological opinion. USFWS reached this conclusion for both the spectacled eider and the Steller's eider (candidate species at the time) due to the apparently limited overlap in range between these eider species and the groundfish fisheries.

Conditions for Reinitiation of Consultation. For all ESA listed species, consultation must be reinitiated if: the amount or extent of taking specified in the Incidental Take Statement is exceeded, new information reveals effects of the action that may affect listed species in a way not previously considered, the action is subsequently modified in a manner that causes an effect to listed species that was not considered in the biological opinion, or a new species is listed or critical habitat is designated that may be affected by the action.

Impacts of the Alternatives on Endangered or Threatened Species. Designation of EFH under Alternative 2 or 3 would not affect the prosecution of the salmon, scallop, BSAI crab or groundfish fisheries of the BSAI or GOA in a way not previously considered in the above consultations. The EFH alternatives are administrative in nature, and no impact on the human environment will result from any alternative because no regulatory changes are proposed with this action. It is expected that implementation of the preferred alternative will be of long-range benefit to the human environment. Improved understanding of EFH, and future management measures taken to protect EFH, can be expected to result in increases in fish populations upon which threatened and endangered species feed. None of the alternatives would affect overall Total Allowable Catch (TAC) amounts, Prohibited Species Catch (PSC) limits, or takes of listed species. Therefore, none of the alternatives are expected to have a significant impact on endangered, threatened, or candidate species.

2.5 Impacts on Marine Mammals

Marine mammals not listed under the ESA that may be present in the BSAI include cetaceans, [minke whale (*Balaenoptera acutorostrata*), killer whale (*Orcinus orca*), Dall's porpoise *(Phocoenoides dalli*), harbor porpoise (*Phocoena phocoena*), Pacific white-sided dolphin (*Lagenorhynchus obliquidens*), and the beaked whales (e.g., *Berardius bairdii* and *Mesoplodon spp*.)] as well as pinnipeds [northern fur seals (*Callorhinus ursinus*), and Pacific harbor seals (*Phoca vitulina*)] and the sea otter (*Enhydra lutris*).

None of the alternatives would affect takes of marine mammals. Because the alternatives are administrative in nature and do not impose any regulatory changes, they will not alter the harvest of groundfish, crab, scallops, or salmon. Therefore, none of the alternatives are expected to have a significant impact on marine mammals.

2.6 Coastal Zone Management Act

Implementation of each of the alternatives would be conducted in a manner consistent, to the maximum extent practicable, with the Alaska Coastal Management Program within the meaning of Section 30(c)(1) of the Coastal Zone Management Act of 1972 and its implementing regulations.

2.7 Conclusions or Finding of No Significant Impact

None of the FMP amendment alternatives are likely to significantly affect the quality of the human environment, and the preparation of an environmental impact statement for the proposed action is not required by Section 102(2)(C) of the National Environmental Policy Act or its implementing regulations.

____ ____________________________

Assistant Administrator for Fisheries, NOAA Date

3.0 REFERENCES

Dau and Kitchinski. 1977. Seasonal movements and distribution of the spectacled eider. Wildfowl 28:65-75.

Federal Register. 1988. Proposed Rule for ESA listing status change of west coast chinook salmon. 3/9/98: 11482-11520.

Flint, V. E., Boehme, R. L., Kostin, Y. V., and Kuznetson, A. A. 1984. A Field Guide to the Birds of the USSR. Princeton University Press, New Jersey.

Gordon, D.A. 1994. Lingcod fishery and fishery monitoring in Southeast Alaska. Alaska Fishery Research Bulletin. 1(2)140-152.

Heifetz, J. and D. Ackley. 1997. Bycatch in rockfish fisheries of the Gulf of Alaska. Presented to the North Pacific Fishery Management Council during its April 1997 meeting.

King, J., and Dau, C. 1981. Waterfowl and their habitats in the eastern Bering Sea. in The Eastern Bering Shelf: Oceanography and Resources. D. W. Hood, J. A. Calder, Eds. pp. 739-428 (NOAA, Office of Marine Pollution Assessment. University of Washington Press, Seattle, WA., vol. 2.

Metzner, K. A. 1993. Unpublished M.S. thesis. University of Missouri, Columbia.

National Marine Fisheries Service (NMFS). 1997. Final Environmental Assessment for 1996 Total Allowable Catch Specifications. NMFS-Alaska Region, P.O. Box 21668, Juneau, Alaska 99802-1668.

NMFS. 1996. Endangered Species Act. Section 7. Biological Opinion--Fishery Management Plan for the Bering Sea and Aleutian Islands and Gulf of Alaska Groundfish Fisheries and the Total Allowable Catch Specification and its effects to Steller Sea Lions. NMFS Alaska Region, P.O. Box 21668, Juneau, Alaska, January 26, 1996.

NMFS. 1995. Endangered Species Act. Section 7. Reinitiation of Consultation on the Effects of the Groundfish Fisheries Conducted under the Bering Sea and Aleutian Islands and Gulf of Alaska Fishery Management Plans of the North Pacific Fishery Management Council. (Pacific salmon; amended Biological Opinion from January 14, 1994) NMFS Northwest Region, 7600 Sand Point Way, NE, BIN 15700, Seattle, Washington, December 7, 1995.

NMFS. 1994. Endangered Species Act Section 7. Biological Opinion--Pacific Salmon. Reinitiation of Consultation on the Effects of the Groundfish Fisheries Conducted under the Bering Sea and Aleutian Islands and Gulf of Alaska Fishery Management Plans of the North Pacific Fishery Management Council. (Pacific Salmon) NMFS Northwest Region, 7600 Sand Point Way, NE, BIN 15700, Seattle, Washington, January 14, 1994.

NMFS. 1992. Endangered Species Act. Section 7. Biological Opinion--Amendment 18 to the Fishery Management Plan for the Groundfish Fishery of the Bering Sea and Aleutian Islands (Steller Sea Lions). NMFS Alaska Region, P.O. Box 21668, Juneau, Alaska, March 4, 1992.

NMFS. 1991. Endangered Species Act. Section 7. Biological Opinion--Fishery Management Plan for the Bering Sea and Aleutian Islands and Gulf of Alaska Groundfish Fisheries and the Total Allowable Catch Specification and its effects to Steller Sea Lions. NMFS Alaska Region, P.O. Box 21668, Juneau, Alaska, April 18, 1991.

National Marine Fisheries Service (NMFS). 1993. Section 7 Consultation - Biological Opinion: 1992/1993 season and 1993/94 winter season regulations under the fishery management plan for salmon fisheries off the coast of Alaska. Northwest Region, 7600 Sand Point Way NE, BIN C 15700, Bldg 1, Seattle, Washington. May 28, 1993. 74 pp.

National Marine Fisheries Service (NMFS). 1994. Section 7 Consultation - Biological Opinion: 1993/1994 season and 1994/95 winter season regulations under the fishery management plan for salmon fisheries off the coast of Alaska. Northwest Region, 7600 Sand Point Way NE, BIN C 15700, Bldg 1, Seattle, Washington. June 29, 1994. 36 pp.

National Marine Fisheries Service (NMFS). 1995. Section 7 Consultation - Biological Opinion: 1994/1995 season and 1995/96 winter season regulations under the fishery management plan for salmon fisheries off the coast of Alaska. Northwest Region, 7600 Sand Point Way NE, BIN C 15700, Bldg 1, Seattle, Washington. June 30, 1995. 28 pp. plus Attachment 1, 29 pp. and Attachment 2, 7 pp.

National Marine Fisheries Service (NMFS). 1996. Section 7 Consultation - Biological Opinion: 1995/1996 season and 1996/97 winter season regulations under the fishery management plan for salmon fisheries off the coast of Alaska. Northwest Region, 7600 Sand Point Way NE, BIN C 15700, Bldg 1, Seattle, Washington. June 28, 1996. 30 pp. plus Attachment 1, 29 pp. and Attachment 2, 7 pp.

National Marine Fisheries Service (NMFS). 1997. Section 7 Consultation - Biological Opinion: 1996/1997 season and 1997/98 winter season regulations under the fishery management plan for salmon fisheries off the coast of Alaska. Northwest Region, 7600 Sand Point Way NE, BIN C 15700, Bldg 1, Seattle, Washington. July 24, 1997. 30 pp.

National Marine Fisheries Service (NMFS). 1995a. Section 7 Consultation - Biological Opinion: Authorization to Take Humpback Whales (*Megaptera novaeangliae*) from the Central North Pacific Stock Incidental to Commercial Fishing Operations under Section 101(a)(5)(E) of the Marine Mammal Protection Act. Alaska Region, P.O. Box 21668,

Juneau, Alaska. 8 pp.
National Marine Fisheries Service (NMFS). 1995b. Section 7 Consultation - Biological Opinion: Authorization to Take Steller Sea Lions (*Eumetopias jubatus*) Incidental to Commercial Fishing Operations under Section 101(a)(5)(E) of the Marine Mammal Protection Act. Alaska Region, P.O. Box 21668, Juneau, Alaska. 10 pp.
National Marine Fisheries Service (NMFS). 1995c. Proposed Recovery Plan for Snake River Salmon. March 1995. USDC NOAA, Northwest Region, 7600 Sand Point Way NE, BIN c 15700, Bldg 1, Seattle, Washington.
National Marine Fisheries Service (NMFS). 1995d. Section 7 Consultation - Biological Opinion: 1994/1995 season and 1995/96 winter season regulations under the fishery management plan for salmon fisheries off the coast of Alaska. Northwest Region, 7600 Sand Point Way NE, BIN c 15700, Bldg 1, Seattle, Washington. June 30, 1995. 29 pp.
National Marine Fisheries Service (NMFS). 1996b. Section 7 Consultation - Biological Opinion: 1995/1996 season and 1996/97 winter season regulations under the fishery management plan for salmon fisheries off the coast of Alaska. Northwest Region, 7600 Sand Point Way NE, BIN c 15700, Bldg 1, Seattle, Washington. June 28, 1996. 28 pp with attachments.
National Marine Fisheries Service (NMFS). 1997. Section 7 Consultation - Biological Opinion: 1996/1997 season and 1997/1998 winter season regulations under the fishery management plan for salmon fisheries off the coast of Alaska. Northwest Region, 7600 Sand Point Way NE, BIN c 15700, Bldg 1, Seattle, Washington. July 24, 1997. 30 pp with 2 attachments.
North Pacific Fishery Management Council (NPFMC). 1990. Fisheries Management Plan For The Salmon Fisheries In The EEZ Off The Coast Of Alaska. North Pacific Fishery Management Council, P.O. Box 103136, Anchorage, Alaska 99510. 51 pp + appendices.
North Pacific Fishery Management Council (NPFMC). 1997. Economic Status of the Groundfish Fisheries off Alaska, 1995 - Stock Assessment and Fishery Evaluation Report for the Groundfish Resources of the Bering Sea/Aleutian Islands and for the Gulf of Alaska as projected for 1998. November 1997.
O'Connell, V..M. 1993. Submersible observations on lingcod, Ophiodon elongatus, nesting below 30 m off Sitka, Alaska. Mar. Fish. Rev. 55(1):19-24.
O'Connell, V..M and D.C. Carlile. 1993. Habitat specific density of yelloweye rockfish (Sebastes ruberrimus) in the eastern Gulf of Alaska. Fish. Bull. 91:304-309.
O'Connell, V. M., D.C. Carlile, and C. Brylinsky. 1997. Demersal Shelf Rockfish. IN Stock Assessment and Fishery Evaluation Report For 1998. Report to North Pacfic Fishery Management Council, Anchorage AK.
Peterson, M.R. 1980. Observations of wing-feather moult and summer feeding ecology of Steller's eiders at Nelson Lagoon, alaska. Wildfowl. 31:99-106.
Quakenbush, L. and Cochrane, J. F. 1993. Report on the conservation status of the Steller's eider (*Polystica stelleri*), a candidate threatened and endangered species. USFWS, Anchorage, AK. Unpublished report, 26 pp.
Sands, N. J. and J. P. Koenings. 1997. The Biological Assessment for the Southeast Alaska salmon fishery for 1997-2003 Under Section 7 of the Federal Endangered Species Act. Regional Information Report No. 5J97-04. ADF&G, P.O. Box 25526, Juneau, AK 99802. 38 pp + attachments.
Troy, D. M. and Johnson, S. R. 1987. Marine Birds. in Population Estimation, productivity, and food habits of nesting seabirds at Cape Peirce and the Pribilof Islands, Bering Sea, Alaska. S. R. Johnson, Ed. pp. 34-190 (LGL Ecological Research associates, Inc., Anchorage, AK).
United States Fish and Wildlife Service (USFWS). 1997. Letter from Ann G. Rappoport to Steven Pennoyer, February 19, 1997, on effects of the 1997 Total Allowable Catch Specifications and Environmental Assessment for groundfish fisheries in the Gulf of Alaska and Bering Sea-Aleutian Islands on short-tailed albatrosses. USDI USFWS, 605 West 4th Avenue, Room 62, Anchorage, AK 99501.
USFWS. 1995. Endangered Species Act. Section 7. Reinitiation of Consultation on the Effects of the Groundfish Fisheries Conducted under the Bering Sea and Aleutian Islands and Gulf of Alaska Fishery Management Plans of the North Pacific Fishery Management Council. (Seabirds; amended Biological Opinion from July 3, 1989). USDI USFWS, 605 West 4th Avenue, Room 62, Anchorage, AK 99501.
USFWS. 1993. Alaska Seabird Management Plan. Report of the US Fish and Wildlife Service. Anchorage. 102 pp.
USFWS. 1989. Endangered Species Act. Section 7 Consultation on the Effects of the Groundfish Fisheries Conducted under the Bering Sea and Aleutian Islands and Gulf of Alaska Fishery Management Plans of the North Pacific Fishery Management Council. (Seabirds; Biological Opinion.) USDI USFWS, 605 West 4th Avenue, Room 62, Anchorage, AK 99501.

4.0 AGENCIES AND INDIVIDUALS CONSULTED

Lauren Smoker, Jonathan Pollard
NOAA GC
Alaska Region

Earl Krygier, Doug Eggers, Janet Schemph
ADF&G
Juneau, AK

Rich Marasco, Jim Balsiger, K Koski
NMFS-AFSC
Seattle, WA

Clarence Pautzke
NPFMC
Anchorage, AK

Jeanne Hanson
NMFS-AKRO
Anchorage, AK

Steve Zimmerman
NMFS-AKRO
Juneau, AK

Cyries Schmidt
NMFS - NWFSC
Seattle, WA

Mike Dahlberg, Jeep Rice
NMFS-AFSC
Auke Bay Lab

Ramona Schrieber, Lee Crockett, Russ Belmer
NMFS Headquarters
Silver Spring, MD

Ron Berg, Jay Ginter
NMFS -AKRO
Juneau, AK

Gregg Williams
IPHC
Seattle, WA

NPFMC Advisory Panel
NPFMC Scientific and Statistical Committee
NPFMC Ecosystem Committee

Chris Blackburn
Alaska Groundfish Data Bank

John Gauvin
Groundfish Forum

Steve Ganey
Alaska Marine Conservation Council

Captain Vince O'Shea
United States Coast Guard
Juneau, Alaska

5.0 LIST OF PREPARERS

This NEPA document was prepared by members of the EFH Core Team, with additional contributions from scientists within the National Marine Fisheries Service (NMFS), the Alaska Department of Fish and Game (ADF&G), and the International Pacific Halibut Commission (IPHC). Cindy Hartmann (NMFS) coordinated the Core Team activities. Dave Witherell (NPFMC) coordinated the preparation of the EA.

5.1 Members of the EFH Core Team

David Witherell NPFMC Anchorage, AK	Jeff Short, Mike Murphy NMFS AFSC Auke Bay, AK	NMFS AKRO Anchorage, AK
Lowell Fritz NMFS AFSC Seattle, WA	Jeff Fujioka NMFS AFSC Auke Bay, AK	Tamra Faris NMFS AKRO Juneau, AK
Cindy Hartmann NMFS AKRO Juneau, AK	Matt Eagleton	
Steve Waste NMFS Headquarters Silver Spring, MD		

5.2 Other Contributors

ADF&G: Tory O'Connell, Gordon Kruse, Ivan Vining, Peggy Murphy, Fritz Funk, Doug Pengilly, Al Spalinger, Rance Morrison, Dan Urban.

NMFS: Rebecca Reuter, Angie Greig, Jon Heifetz, Jerry Reeves, Bob Otto, Dave Clausen, Anne Hallowed, Dan Ito, Sandra Lowe, Michiyo Shima, Grant Thompson, Vidar Wespestad, Tom Wilderbuer, Bruce Wing, Bill Heard, Jack Helle, Mitch Lorenz, Mike Murphy, Jerry Taylor, Alex Wetheimer, Jim Thomas, Bob Stone, Chuck O'Clair, Kim Rivera, Cyries Schmidt

IPHC: Bob Trumble, Lauri Saudoris

University of Alaska - Tom Shirley

6.0 NMFS RECOMMENDATION ON THE DESCRIPTION AND IDENTIFICATION OF EFH

NMFS FINAL Recommendations
for the
Identification and Description
of ESSENTIAL FISH HABITAT
for
Species of the Fishery Management Plans
of the
North Pacific Fishery Management Council

This document contains the NMFS final recommendations for the identification and description of essential fish habitat (EFH) for species managed under the fishery management plans (FMPs) of the North Pacific Fishery Management Council (NPFMC). This document also provides NMFS endorsements of other components of the EFH FMP amendment requirements as provided in the interim final rule implementing the EFH provisions of the Magnuson-Stevens Fishery Conservation and Management Act (62 Fed. Reg. 66531; December 19, 1997).

Development of NMFS EFH Recommendations: Public Involvement Process

The Magnuson-Stevens Act and the EFH regulatory guidelines require NMFS to consult with the Councils, participants in the fishery, interstate commissions, Federal agencies, state agencies, other interested parties and the public in general while developing written recommendations for the identification of EFH. Prior to submitting final EFH recommendations, the regulatory guidelines require NMFS to make draft recommendations for public review available and to hold a public meeting at which the public can comment.

To meet these requirements, the NMFS Alaska Region established a Core Team in April 1997. The Core Team is composed of NMFS employees and one person from the NPFMC staff. The NPFMC, working with the Core Team, developed a tasking plan which established four technical teams (for salmon, crab, scallop and groundfish). The technical teams were comprised of biologists from the NPFMC, NMFS, the Alaska Department of Fish and Game (ADF&G) and from the USDA Forest Service. All are Federal or state agencies responsible for managing the species covered by the specific FMP or for managing the habitats essential to these species. The technical teams developed habitat assessment reports for each FMP , which were distributed for public comment in December 1997. Updated versions were made available on March 31, 1998. These reports, which form the basis of NMFS's final recommendation, are titled:

- Essential Fish Habitat Assessment Report for the Groundfish Resources of the Bering Sea and Aleutian Islands Regions
- Essential Fish Habitat Assessment Report for the Groundfish Resources of the Gulf of Alaska Region
- Essential Fish Habitat Assessment Report for the Bering Sea and Aleutian Islands King and Tanner Crabs
- Essential Fish Habitat Assessment Report for the Scallop Fisheries Off the Coast of Alaska
- Essential Fish Habitat Assessment Report for the Salmon Fisheries in the EEZ off the

Coast of Alaska.

The Core Team directed the activities of the technical teams and reviewed, commented on and sometimes supplemented their reports. The Core Team held four meetings between May 1997 and March 1998: May 20 - 22, 1997, in Juneau; July 15 - 17, 1997, in Juneau; October 21-23, 1997 in Seattle; and March 2 - 5, 1998, in Juneau. The meetings were open to the public and the public was encouraged to participate. In these meetings the Core Team discussed how to meet the EFH requirements of the Magnuson-Stevens Act, reviewed the information compiled by the technical teams, and made the necessary assignments to gather more information as necessary. On March 4 and 5, 1998, NMFS-only members of the Core Team met to develop the NMFS draft EFH recommendation. The meeting was not open to the public on these two days. The Core Team also had teleconferences as necessary. In general, because of time constraints, the public was not notified or encouraged to participate in these teleconferences.

In addition to Core Team meetings, evening public meetings were held in various communities around the state. These meetings were as follows: February 5, 1997, in Anchorage, to discuss the proposed rule to establish EFH regulatory guidelines in accordance with Section 3D5(b)(1) of the Magnuson-Stevens Act; February 6, 1997, in Kodiak, to discuss the proposed rule; May 21, 1997, in Juneau, to discuss the proposed rule; February 4, 1998, in Anchorage, to discuss the effects of fishing on fish habitat; February 5, 1998, in Anchorage, to discuss the draft habitat assessment reports and other information compiled for EFH, and to discuss the interim final rule; March 3, 1998, in Juneau, to discuss the EFH information and documents and the interim final rule.

EFH was an agenda item on the Council's December 1996, February 1997, June 1997, February 1998, and April 1998 meetings. At the February 1998 Council meeting, members of the Core Team gave public presentations on the habitat assessment reports prepared by the technical teams to the Council, its Scientific and Statistical Committee (SSC) and its Advisory Panel (AP). Comments provided by the Council, the SSC, the AP, and the public were subsequently incorporated into the habitat assessment reports. During the February Council meeting, a public meeting was held the evening of February 4, 1998, at which one of the authors of a paper analyzing the impacts of fishing gear on habitat presented their preliminary findings for discussion. The following evening, a public EFH workshop was held on the status of EFH development for the Alaska Region. Questions and comments were invited on the development of EFH and on the draft EFH documents. Many of the comments received during this week were incorporated into the preliminary habitat assessment reports.

At the April 1998 Council meeting, the Core Team again gave presentations to the Council, the SSC, AP and the public during Council and committee discussions and also at an evening EFH workshop. The presentations focused on the draft NMFS EFH recommendations, including textual descriptions of EFH for each species life stage, levels of information for each life stage, and the draft Environmental Assessment (EA). Comments from the Council, SSC, AP and the public on the draft NMFS recommendations and EA were provided to the Core Team. Those comments are incorporated into the final NMFS recommendations and supporting documents. The NMFS Alaska Regional office also received two comment letters on the draft EFH recommendations, which are attached to this document for Council review.

For each of the public meetings mentioned above, efforts were made to reach as many interested parties as possible, including non-fishing entities. Based on the foregoing activities, NMFS has met the public participation requirements of the Magnuson-Stevens Act and the EFH regulatory guidelines in developing the EFH recommendations contained in this document.

Explanation of Key Concepts

In terms of process, the formation of the NMFS recommendations was guided by the application of a four-tiered typology of information, and the development of a definition of "general distribution" suitable for serving as the basis for identifying EFH.

Levels of Information

NMFS's EFH guidelines provide a typology of information (Levels 1 to 4) for classifying available information on the distribution of a life stage. The technical teams deemed it necessary to also define "Level 0" information as a subset of Level 1. Level 0 is intended to define a level of knowledge less than Level 1, which requires presence/absence data sufficient for applying analyses of frequency of occurrence. Level 0 information is defined by the Groundfish Technical Team as: “No systematic sampling has been conducted for this species and life stage; may have been caught opportunistically in small numbers during other surveys.” The BSAI Crab Technical Team used nearly the same definition for Level 0, but specified “research” surveys.

In general, Level 0 classification was used in the following situations:

a) some information on a species’ life stage upon which to infer general distribution;
b) no information on the life stage, but some information on a similar species or adjacent life stages from which to infer general distribution; or
c) no information on the actual species’ life stage and no information on a similar species or adjacent life stages, or where complexity of a species stock structure prohibited inference of general distribution.[1]

Thus, in some cases EFH for a species life stage was inferred using Level 0 (a) and (b) information. However, EFH was not inferred for Level 0 (c), cases where no information was available on the actual species’ life stage and no information was available on a similar species or adjacent life stages, or where stock structure prevented inference from adjacent life stages or other species. Cases where no information exists on a particular species’ life stage, nor on similar species or adjacent life stages from which a general distribution might be inferred, were considered research priorities if the species at that life stage was likely to depend on habitat at risk from human activities. (Please note that the technical teams' definitions of Level 0 may differ slightly, depending on how they applied the concept using available information on a particular FMP species.)

At the April 1998, NPFMC meeting, the SSC and the Council asked NMFS to clarify the definition and use of the sub-tiers of Level 0 information. This discussion of Level 0 and the attached description and identification of EFH provide clarification. For species life stages that have Level 0 information the EFH definition is identified as Level 0_a, Level 0_b, or Level $0_{c;}$ no EFH definition is provided for Level 0_c. Supporting summary tables are appropriately footnoted.

General Distribution

---

[1] This explanation of Level 0 supersedes prior descriptions of Level 0 in supporting documents.

The technical teams determined that information of Levels 0 and 1 was available for most life stages. Information of Level 2 was generally available for adult life stages. Higher levels of information (Levels 3 & 4) were available for some life stages of salmon in some regions of Alaska. From this information, the technical teams provided estimates of the general distributions and known concentrations for their respective species. The determinations of general distribution and known concentration were done independently by each technical team. In each case, a general distribution of a species' life stage was defined as a subset of its current and historic range, and as the geographic area containing most of the individuals across all seasons. Thus, general distribution is not a proxy for, but rather a subset of range, and varies in size depending on the species.

When defining EFH the Core Team looked at all life stages of all FMP-managed species. From these life history traits, the Alaska Region Core Team found the overall distribution to be all waters -- marine, estuarine, and riverine -- to the headwaters of freshwater systems. To avoid defining EFH to be inclusive of all waters, the NMFS members of the Alaska Region Core Team narrowed the definition of EFH to a general distribution. The term "general distribution"does not include the entire species range, but denotes areas where most of the individuals are found, or where one would reasonably (with a high probability) expect to find a certain life stage of that species. General distribution encompasses approximately 95 percent of the total population.

The estimation of general distribution varied among technical teams in regard to the level of information. For example, for life stages with information Level 0, (a) and (b), the Salmon and Groundfish Technical Teams decided there was enough information available to infer general distribution (except for some forage fish species). For a life stage lacking direct information, general distribution was inferred from information on a similar species or distribution of an adjacent life stage. The methods for determining the salmon and groundfish general distributions and known concentrations are indicated in the respective habitat assessment reports. While differing slightly in process due to differences in type of data sources and habitat, the results are similar in degree of inclusiveness for similar amounts of information.

The Scallop Technical Team felt there was enough information to infer general distribution for species life stages with Level 0 information, except for the larval stages of Pink, Spiny, and Rock Scallops. The Crab Technical Team provides habitat association information for many species life stages; however, it made no inference of the geographic general distribution for any life stages with Level 0 information. While the lesser degree of inference in the Crab Technical Team recommendations is due in part to less information and a lesser degree of inclusiveness, inferring general distribution for crab is more complex due to the apparent stock structure of crabs. Up to five different stocks per crab species are identified in the Bering Sea, while for groundfish only one stock per species is identified. The general distributions of adjacent species or life stages where knowledge is at Level 2 tend to show discrete distributions in crab, compared to more contiguous distributions of groundfish. Thus interpolating or extrapolating inferred distributions is a more complex process for crab stocks. The Salmon and Groundfish technical teams inferred general distribution when some information was available upon which to make an inference. However, general distribution for some forage species was not inferred for life stages when there was no information on the life stage itself and no information on adjacent life stages or similar life stages of similar species. Thus, for Level 0_c life stages, general distribution is not provided and EFH is not defined.

Known Concentrations

Known concentrations were defined only for life stages for which Level 2 knowledge is available. (Level 2 information was only available for certain adult stages in the case of groundfish and shellfish, and certain life stages for salmon).

NMFS FINAL EFH RECOMMENDATIONS

The documents and explanations listed above comprise the basis of the NMFS final EFH recommendations and preliminary endorsements that follow.

Final Recommendation for Identification and Description of EFH

The NMFS members of the Alaska Region Core Team considered the alternatives of using general distribution or known concentrations to define EFH for species' life stages for which Level 2 or higher information is available. A principal concern was that using known concentrations alone to designate EFH would not ensure that adequate areas were protected as EFH. NMFS supports the conclusions of the technical teams and the conclusions of the NMFS members of the Alaska Region Core Team concerning the use of general distribution rather than known concentration to define EFH and has adopted their rationale as the basis for the NMFS final recommendation.

The NMFS final recommendation for identification and description of EFH is:

> **EFH is defined as all habitat within a general distribution for a species life stage, for all information levels and under all stock conditions. A general distribution area is a subset of a species range. For any species listed under the Endangered Species Act, EFH includes all areas identified as "critical habitat."**

The NMFS final recommendation for the identification and description of EFH corresponds to Alternative 2 of the draft EFH EA.

NMFS based this recommendation on the following rationale:

- Areas of known concentrations based on current information do not adequately address unpredictable annual differences in spatial distributions of a life stage, nor changes due to long-term shifts in oceanographic regimes.

  Groundfish and salmon provide examples of this rationale. Annual differences in distribution of high concentrations of adults, particularly for pelagic or semi-demersal species (e.g., pollock, Pacific cod) occur and are unpredictable. Within the last 20 years, during which most data have been obtained, long-term changes in concentrations have been observed in Alaska groundfish. The spawning distribution of Gulf of Alaska pollock has changed dramatically since the 1970s. Relative distribution of the Alaska sablefish stock between the Bering Sea, Aleutian Islands, and the Gulf of Alaska has cycled since the late 1970s.

  Habitat productivity for salmon also varies cyclically with natural long-term disturbance regimes, so that a particular watershed may have low productivity after an event such as a major flood, followed by a period of higher productivity. Locations of salmon concentrations in freshwater, estuarine, and marine habitats may change unpredictably, so that current areas of known concentration would not adequately cover required habitat.

Regime shifts in ocean conditions due to climate change can also cyclically affect physical conditions, abundance of food or predators, and, as a result, the distribution and survival of salmon. Current areas of known concentrations, therefore, may not adequately cover required habitats. For example, a regime shift in the climate of the North Pacific Ocean in the 1970s altered the distribution and production dynamics of salmonids. The upper thermal limit of the distribution of steelhead in the high seas increased after the regime shift, and this change in distribution is thought to have been caused by increased ocean productivity and increased intensity of the Aleutian Low pressure system. The best model fitting changes in the productivity of Bristol Bay sockeye salmon included a one-time change in the parameters of the Ricker stock and recruitment model, which first affected the 1972 brood year. Unpredictability of such regime shifts and limited knowledge of how salmon respond to such changes in ocean conditions necessitate a conservative description of essential fish habitat.

A growing body of evidence indicates that such a regime shift is currently underway, and is associated with further significant declines in marine survival of salmon in the Pacific Northwest and British Columbia. Alaska salmon stocks are also affected; a dramatic 45% reduction occurred in the commercial harvest over the past 2 years (218 million fish caught in 1995; 121 million in 1997). Designating only habitat with current high abundance or productivity as EFH ignores the implications of such short- and long-term cycles.

C All habitats occupied by a species contribute to production at some level. Although contributions from individual locations may be small, collectively they can account for a significant part of total production. For example, fisheries for coho and pink salmon depend on the cumulative production from thousands of small streams that are widely distributed across coastal Alaska.

C A stock's long-term productivity is based on both high and low levels of abundance, and the entire general distribution may be required during times of high abundance. The total recruitment history, both high and low levels, are used in the estimation of biological reference points for many of the groundfish species managed by the NPFMC. These reference points are intended to relate to the stock's long-term productivity. $B_{40\%}$, for example, is often considered a default or surrogate for the biomass that would produce MSY.

For example, salmon use a broader range of freshwater habitat during periods of high abundance. The broad range and diversity of salmon habitats must be conserved to provide for periods of abundance, as well as to avoid severely reduced production during poor years. Similarly, high concentrations of rock sole were found in only two discrete areas of the southeastern Bering Sea during periods of low abundance (early 1980s), but were found throughout regions with 100 m water depth in times of high abundance (mid 1990s).

C Survey information, upon which descriptions of known concentrations are primarily based, is limited to certain seasons (chiefly summer), while the general distribution is based on the best available scientific information, as well as fishery and local knowledge of a life stage.

- No discrete basis exists, or no threshold is defined, to distinguish between known concentrations and general distribution of a species' life stage.
- Observed concentrations or densities do not necessarily reflect all habitat required to maintain healthy stocks within the ecosystem.
- From a scientific perspective, no rationale was found to identify areas outside of a known concentration as non-essential for maintaining healthy production levels without extensive knowledge of habitat-related linkages to productivity and the ecosystem. Substantial rationale exists, however, to justify an inclusive definition of EFH using general distribution.
- The advice in the NMFS guidelines to use the best scientific information available in a risk-averse fashion and employ an ecosystem approach suggests that, unless the information indicates otherwise, the more inclusive general distribution should be used to designate EFH. From the examples above, it is clear that density knowledge alone (Level 2 information) would be insufficient to determine that the habitat encompassed by general distribution is not essential to maintain healthy stocks and ecosystems and sustain productive fisheries. While it may be possible to make such a determination at higher levels of knowledge, NMFS is not making such a determination at this time.
- In the case of juvenile and adult salmon in marine waters, our greater knowledge of their habitat utilization indicates that they are indeed distributed over a larger expanse of the Pacific Ocean than is encompassed by the EEZ. As scientists obtain more knowledge on certain species, as in the case of salmon, they are learning that salmon spatial habitat requirements can actually be much greater and not as concentrated as one might expect. This broad geographic distribution of essential habitats provides the prey species important for their growth and maturation as well as the habitat diversity required in times of changing environmental conditions.

With respect to Alternative 3 in the EA, it would only be possible to delineate areas of known concentration of salmon in some watersheds. First, one would identify watersheds with sufficient information and then delineate areas of known concentration within the watersheds. This would only be possible for a small number of watersheds, and generally only for adult salmon. It could be done for juvenile salmon in a few watersheds. For marine habitat, some areas of known concentration have been identified, but current information is not comprehensive and mainly reflects migration habitat. Most ocean areas have not been adequately surveyed, so that it is not possible to identify areas of concentration that are essential for growth and survival of maturing and adult salmon.

In response to comments received on the NMFS draft recommendations some changes have been made in EFH has been described or displayed. These changes include depiction of salmon EFH and clarification of EFH when Level 0 information is available.

Salmon EFH

We recommend that the Council not include the marine maps previously submitted for salmon. We would like to substitute the maps attached to this document, for the following reasons:

> Areas of known concentration of maturing and adult salmon in the marine environment have been identified for some species based on bycatch in fisheries, such as chinook, sockeye, and chum salmon bycatch in the Bering Sea trawl fishery. These known concentrations, however, reflect points where fish become concentrated on migration routes from the open ocean to fresh water

(e.g., Unimak Pass); they do not indicate exceptional habitats necessary for rearing and maturing. In addition, NMFS research has identified the area off Prince William Sound to Kodiak Island as a possible area of concentration of chum salmon in summer. Current knowledge of salmon distribution in the ocean is inadequate to identify other concentrations or areas of exceptional production.

The concept of "areas of known concentration" as used for marine EFH applies differently to salmon in fresh water. In fresh water, concentrations of salmon reflect locations of specific habitats for spawning, rearing, and migration that are patchily distributed on a finer scale (at the reach level) within watersheds. Freshwater habitat is very heterogeneous, and at a local level, depends on geomorphic, vegetative, hydrologic, and other factors, and also varies along the "river continuum" from headwaters to river mouth. Therefore, the distribution of habitat and fish within specific watersheds must be considered on a case-by-case basis to identify areas of concentration. Such areas of concentration, usually of spawning adult salmon, have been identified for a small number of specific river systems that have been intensively surveyed, primarily in Southeast (Region I), Southcentral (Region II); and Southwestern (Region III) Alaska. By radio tagging, for example, NMFS research has identified areas of concentrated chinook and sockeye salmon spawning in the Taku River, which could be considered areas of known concentration. For the vast majority of watersheds, however, information is insufficient to identify areas of known concentration, particularly for juvenile salmon.

The general distribution of salmon in fresh water includes virtually all the coastal streams to about 70° N latitude. Maps of documented salmon occurrence in fresh water (representing only a subset of salmon EFH) are available in the ADF&G stream Atlas. These maps show presence/absence of anadromous fish in areas that have been surveyed, but do not show fish densities, and therefore, they do not depict areas of known concentration.

Alternative 3

For clarification, NMFS wants the Council and the public to understand that the Descriptions and identification of EFH are written to describe the general distribution of a species life stage. The legal EFH definition is the written or text definition. For most species life stages the text is supported with maps. Maps were drawn for species with Level 1 or higher information. No maps are provided for those life stages with Level 0 information. For species with Level 2, or higher information, known concentrations are drawn on the maps within the general distribution (with the exception of salmon). For salmon, areas of known concentration are as described above.

If the Council chooses Alternative 3 of the EA more staff work is needed to both visually display (this pertains to salmon only) and verbally describe EFH in writing. However, enough information is included for the Council to make an informed decision.

Final Recommendation for Habitat Areas of Particular Concern

NMFS recommends the following general types of habitat be considered potential locations for habitat areas of particular concern (HAPC) for all FMP-managed species:

1. Nearshore areas of intertidal and estuarine habitats with submerged vegetation, rock, and other

substrates that may provide food and rearing for juvenile groundfish, salmon, and shellfish; spawning or mating areas for adults of some crab and groundfish species (e.g., Atka mackerel, yellowfin sole, red king crab); and migration route areas for adult and juvenile salmon; and that are sensitive to natural or human-induced environmental degradation, especially in urban areas and in other areas adjacent to intensive human-induced developmental activities. Examples include areas such as eelgrass beds, submerged aquatic vegetation, emergent vegetated wetlands, and certain intertidal zones. Many of these areas are unique and rare, and have a high potential to be affected by shore-based activities. The coastal zone is under the most intense development pressure, and estuarine and intertidal areas are limited in comparison with the areal scope of other marine habitats.

2. Offshore areas with substrates of high micro-habitat diversity which serve as cover for groundfish and shellfish. These can be areas with rich epifaunal communities (e.g., coral, anemones, bryozoans, etc.) or with large particle size (e.g., boulders, cobble). Complex habitat structures are considered most readily impacted by fishing activities.

3. Freshwater and estuarine habitat used for migration, spawning, and rearing of anadromous fish, especially in urban areas and in other areas adjacent to intensive human-induced developmental activities.

To identify specific HAPCs within the above general habitat types NMFS will apply the following criteria:

- the importance of the ecological function provided by the habitat;
- the extent to which the habitat is sensitive to human-induced environmental degradation;
- whether, and to what extent, development activities are, or will be, stressing the habitat; and
- the rarity of the habitat type.

For example, an eelgrass bed would be considered a HAPC if it were threatened by development activities.

NMFS recommends the general types of habitat listed above, those identified by the technical teams and those included in Section 11 of the draft EFH EA, be considered as habitat areas of particular concern within the five NPFMC FMPs, whenever one or more of the four criteria (ecological function, sensitivity, stress on the habitat, and rarity) occur. This HAPC evaluation process will be further clarified in a discussion paper that will be available at the June Council meeting. The discussion paper will outline the proposal process by which HAPC could be identified by the public and analyzed by the NPFMC/NMFS for inclusion in an FMP amendment. The discussion paper will also give examples of types of management measures that might address impacts to these habitats.

Final Recommendation on Research and Information Needs

The Alaska Region EFH Core Team has developed a draft strategic framework with which to evaluate activities in the Alaska Region with respect to attaining NMFS habitat goals. To determine where investment of funds and resources should be directed, the framework considers the relative progression or status of the respective FMP species groups in terms of knowledge of habitat requirements, habitat management, and condition of habitat. Briefly, the framework identifies activities that would address the

Level 0 life stages where they are likely to occur in habitat at risk; identifies the means to improve management and compatibility of human activities that affect the critical freshwater habitat of salmon; and identifies ways to evaluate and minimize effects of NMFS managed fisheries on EFH. The NMFS Core Team and Habitat Conservation Division will continue to develop the framework into an effective document.

Individual technical team reports indicate specific management, habitat, and ecological requirements that correspond to research needs in areas at risk. NMFS recommends that these research needs, as well as those identified in the EFH habitat assessments, EFH summary documents and Section 10 of the draft EA, be included in the EFH FMP amendments and pursued by NMFS to enhance knowledge of EFH. NMFS recommends the research needs identified for each FMP by the technical teams (summarized in Section 10 of the DRAFT EFH EA) and the following research needs:

1. Surveys and studies of nearshore pelagic and benthic areas are needed to determine their use by a variety of species, including Atka mackerel, Pacific cod, pollock, rockfish, sablefish, octopus, flatfishes, salmon, crabs, scallops, and juveniles and larvae of all species and forage species considered in NPFMC FMPs.

2. In salmon freshwater habitat, knowledge and management tools are needed for use in conserving or restoring habitat areas of particular concern.

3. Information on habitat distribution, in conjunction with fish distribution, is needed to determine species' habitat requirements and utilization. Information on the extent and distribution of complex habitat types susceptible to bottom fishing will greatly improve the ability to evaluate the potential of a fishery to physically alter bottom habitat and evaluate proposed measures to minimize impacts on EFH. To acquire this information, the Core Team recommends increased support to acquire information on detailed bottom topography and bottom type distribution on the continental shelf and slope.

4. Research necessary to raise the level of information known on a species life stage from Level 0 or 1 to Level 2 or higher.

Endorsement of Identified Fishing and Non-Fishing Threats and Cumulative Impacts Analysis of these Activities

A description and identification of fishing and non-fishing threats is included in the EFH EA at Sections 9.1 and 9.2, respectively. A cumulative impacts analysis of these activities is included in the draft EFH EA at Section 9.4. NMFS endorses the statements made and conclusions reached concerning fishing and non-fishing threats and the cumulative impacts of those activities presented in the draft EFH EA.

Non-fishing adverse impacts to EFH in Alaska identified and discussed include: dredging, fill, excavation, marine mining, fish processing waste, timber harvest, non-point source pollution including urbanization, point source pollution, hazardous material, mariculture, oil and gas activities, hydroelectric projects, marine traffic, and natural adverse impacts. Habitat protection recommendations are summarized in Section 9.1.3 of the EA.

Identification of fishing threats to EFH is discussed in Section 9.2 of the EA. This Section reviews the effects of fishing gear (trawl, dredge, longline, pot and salmon fishing gear) on benthic communities.

Fishery management options that may prevent, mitigate or minimize adverse effects from fishing may include, but are not limited to: fishing equipment restrictions, time/area closures, and harvest limits. Current and planned research on fishing gear and habitat interactions in the North Pacific is summarized in Section 9.2.2 of the draft EA.

Recommendation for Review and Revision of EFH Components of FMPs

The interim final rule states that the Council and NMFS should periodically review the EFH components of each FMP, including an update to the fishing gear impacts assessment of the FMPs. To accomplish this, the original EFH FMP amendment should include a provision requiring a review of the FMP's EFH information in light of new information and the preparation of another EFH FMP amendment to incorporate this new EFH information, if appropriate. The schedule for this review should be based on an assessment of both the existing data and expectations when new data will become available. This information should be reviewed as part of the annual Stock Assessment and Fishery Evaluation (SAFE) report. Furthermore, the interim final rule states that a complete review of EFH components should be conducted as recommended by the Secretary at least once every 5 years.

To incorporate the regulatory guidelines requirement for review and revision of EFH FMP components, NMFS recommends the following:

- First, NMFS recommends that the Council conduct a complete review of all the EFH components of each FMP once every 5 years and that the Council amend those EFH components of any or all FMPs to include relevant new information. Second, NMFS recommends that, in between five-year comprehensive reviews, the Council utilize its annual FMP amendment cycle to solicit proposals on HAPCs and/or conservation and enhancement measures to minimize the potential adverse effects from fishing. Proposals that the Council endorses should be developed independent of the five-year comprehensive EFH review cycle.
- Third, NMFS recommends that an annual review of existing and new EFH information be conducted and this information be provided to the Plan Team for their review during the annual SAFE report process. This information could be included in the "Ecosystems Considerations" chapter of the SAFE report.
- Fourth, NMFS recommends that research and information needs be incorporated into a Strategic Investment Framework developed by the EFH Core Team and updated annually. This framework can be used as a management tool to prioritize budget requests and to prioritize recommendations for expenditures of EFH funds.

Endorsement of Identification of Important Prey Species

NMFS endorses the statements made and conclusions reached concerning important prey species presented in the technical team habitat assessments and in Section 7.0 of the draft EFH EA. Prey species are identified in the individual species reports in the technical team habitat assessments where the information was available. The diet or prey of the FMP species was included as part of the tables that summarized vital life history information for each species.

Section 7.0 of the draft EFH EA discusses important prey species for forage fish and several species of GOA and BSAI groundfish. Forage fish species are abundant fishes that are preyed upon by marine mammals, seabirds and other commercially important groundfish species. Forage fish perform a critical role in the complex ecosystem functions of the Bering Sea and Aleutian Islands management area and the

Gulf of Alaska by providing the transfer of energy from the primary or secondary producers to higher trophic levels. The forage fish species category would include all species of the following families:

Osmeridae (eulachon, capelin and other smelts),
Myctophidae (lanternfishers),
Bathylagidae (deep-sea smelts).
Ammodytidae (Pacific sand lance).
Trichodontidae (Pacific sand lance),
Philidae (gunnels),
Stichaeidae (pricklebacks, warbonnents, eelblennys, cockscombs and shannys),
Gnostomatidae (bristlemouths, lightfishes, and anglemouths), and
the Order *Euphausiacea* (krill).

6.1 BSAI Groundfish

Recommendations for Identification and Description
of Essential Fish Habitat for the Groundfish Resources
of the Gulf of Alaska,
Bering Sea, and Aleutian Islands Regions

by
The Technical Team for Essential Fish Habitat
for the Groundfish Resources of the Alaska Region

Background

The Essential Fish Habitat Assessment Reports (NPFMC 1997a;b) provide summaries and assessments of habitat information for Gulf of Alaska and Bering Sea and Aleutian Islands Region Groundfish species. The team reviewed habitat descriptions and life history information summarized by stock assessment scientists and determined the levels of information available for each life stage of major species in the BSAI and GOA FMPs. The information contained in these summaries along with that contained in data atlases (NOAA 1987; 1990), summaries of fishery and survey data (Allen and Smith 1988; Wolotira et al. 1993; Fritz et al. In press a;b), and fish identification books (Hart 1973; Eschmeyer and Herald 1983) were used to determine the level of knowledge available to identify EFH for each life stage of each major groundfish species. In evaluating the level of knowledge available, the technical team defined a level 0 as a subset of level 1 as defined by NMFS in its guidelines for determining the level of information on the distribution of a life stage. For life stages of BSAI and GOA groundfish, the Team determined that information of level 0, 1, and 2 was available.

From this information, ***general distributions*** of species life stages were defined. A general distribution of a species' life stage is a subset of its current and historic range, and is the geographic area containing most (approximately 95%) of the individuals across all seasons. Habitats occupied by the species' life stage are located within each general distribution. Rare observations that extend a species range during anomalous environmental conditions would not be considered part of its general distribution.

> For life stages with information levels 1 and 2, *general distributions* were determined geographically as the area encompassing at least 95 percent of positive survey samples in Fritz et al. (In press, a;b) and supplemented as necessary by distribution information available in NOAA (1987;1990), Wolotira et al. (1993), and Allen and Smith (1988) to allow for survey coverage limitations, and by any relevant knowledge of life history or habitat associations. Maps illustrating general distributions for species life stages for which level 1 or 2 is available are provided.
>
> For life stages with level 0 information, *general distributions* were inferred from where a species has been observed and any relevant knowledge of its life history and habitat associations. No maps for life stages with level 0 information were drawn.

Areas of ***known concentrations*** within a general distribution were also defined as the approximate area encompassing survey or fishery hauls with density (catch per unit effort) observations in the upper 66th percentile of positive observations of a species life stage in Fritz et al. (In press a;b), and supplemented as necessary by distribution information available in NOAA (1987;1990), Wolotira et al. (1993), and Allen and Smith (1988) to allow for survey coverage limitations, and by any relevant knowledge of life history or habitat associations. *Known concentrations* are defined only for species life stages for which level 2 knowledge is available (only for the adult stages of certain groundfish) and are shown on the accompanying maps.

Recommendations for Identification and Description of Groundfish EFH

The Groundfish Technical Team considered the alternatives of using general distribution or known concentrations to define EFH for species' life stages for which level 2 information was available. The Team's principal concern was that using known concentrations alone to designate EFH would not ensure that adequate areas were protected as EFH. Specific reasons discussed by the Team in support of this conclusion were:

1. Areas of known concentrations based on current information do not adequately address unpredictable annual differences in spatial distributions of a life stage, nor changes due to long term shifts in oceanographic regimes.

   Annual differences in distribution of high concentrations of adults, particularly for pelagic or semi-demersal species (e.g., pollock, Pacific cod) occur and are unpredictable. Within the last 20 years, from which most data has been obtained, long term changes in concentrations have been observed in Alaska groundfish. The spawning distribution of Gulf of Alaska pollock has changed dramatically since the 1970's. Relative distribution of the Alaska sablefish stock between the BS, AI, and GOA has cycled since the late 1970's.

2. All habitats occupied by a species contribute to production at some level. Although contributions from individual locations may be small, collectively they can account for a significant part of total production.

3. A stock's long term productivity is based on both high and low levels of abundance and the entire general distribution may be required during times of high abundance

4. There is a seasonal limitation on survey information (chiefly summer) upon which descriptions of known concentrations are primarily based, while the general distribution is based on the best available scientific information, as well as fishery and local knowledge of a species life stage.

5. There is no discrete basis for the distinction between known concentrations and general distribution of a species' life stage.

6. Observed concentrations or densities do not necessarily reflect all habitat essential to maintain healthy stocks within the ecosystem.

The advice in the NMFS guidelines to use risk-averse and ecosystem approaches and the best scientific information available suggests that the general distribution should be used to designate EFH necessary to maintain healthy stocks and ecosystems and sustain productive fisheries. While areas of known concentration are identified for some species life stage, the Groundfish Technical Team recommends that EFH be defined at this time as the general distribution for all groundfish species life stages in the Gulf of Alaska, Bering Sea and Aleutian Islands.

The recommended EFH definition for each species' life stage is written in the following section and described in Tables 1-3. The habitats described in the text are located within the general distributions shown on maps for species' life stages with level 1 or 2 information. For those stages with level 1 information, only general distributions within which EFH is located are drawn on maps. For those adult groundfish with level 2 information, known concentrations are also drawn on the maps within the general distribution, however EFH is defined as the adult's general distribution. No maps are provided for those life stages with level 0 information.

For BSAI and GOA pollock, a map showing the general distribution of each life stage is provided. For all other groundfish species which have level 1 or 2 information for adult or juvenile life stages, only 1 map is provided. If the adult stage has level 2 information and the juvenile stage has level 1 information, the map displays both the general distribution of adults and juveniles and known concentrations of adults. If only the adult stage has level 1 or 2 information, the map displays its general distribution and known concentrations (only for level 2).

Geographic references used in the written definitions of EFH for BSAI and GOA groundfish are shown in Figure 1. EFH distribution maps are drawn specific to the management areas of concern. For instance, maps of general distributions of BSAI groundfish show the distribution of EFH only in the BSAI region, which includes only management areas between 500-543; it is not drawn east of 170°W south of the Aleutian Islands since that is in the GOA region (management areas between 600-680; Figure 2). Similarly, EFH is not drawn beyond the boundaries of the U.S. Exclusive Economic Zone.

References

Allen, M. J., and G. B. Smith. 1988. Atlas and zoogeography of common fishes in the Bering Sea and northeastern Pacific. U.S. Dep. Commerce, NOAA Tech. Rept. NMFS 66, 151 p.

Eschmeyer, W. N., and E. S. Herald. 1983. A field guide to Pacific coast fishes. Houghton Mifflin Co., Boston. 336 p.

Fritz, L. W., A. Greig, and R. Reuter. Catch-per-unit-effort, length, and depth distributions of major groundfish and bycatch species in the Bering Sea, Aleutian Islands and Gulf of Alaska regions based on groundfish fishery observer data. U.S. Dep. Commerce, NOAA Tech. Memo. NMFS-AFSC. In press (a).

Fritz, L. W., A. Greig, and R. Reuter. Catch-per-unit-effort, length, and depth distributions of major groundfish and bycatch species in the Bering Sea, Aleutian Islands and Gulf of Alaska regions based on research trawl survey data. U.S. Dep. Commerce, NOAA Tech. Memo. NMFS-AFSC. In press (b).

Hart, J. L. 1973. Pacific fishes of Canada. Fisheries Research Board of Canada Bulletin 180. Ottawa. 740 p.

NOAA. 1987. Bering, Chukchi, and Beaufort Seas. Coastal and ocean zones, Strategic assessment: Data atlas. U.S. Dep. Commerce, NOAA, NOS.

NOAA. 1990. West coast of North America. Coastal and ocean zones, Strategic assessment: Data atlas. U.S. Dep. Commerce, NOAA, NOS.

NPFMC. 1997a. Essential fish habitat assessment report for the groundfish resources of the Bering Sea and Aleutian Islands regions. North Pacific Fishery Management Council, 605 W. 4th Ave., Suite 306, Anchorage, AK 99501.

NPFMC. 1997b. Essential fish habitat assessment report for the groundfish resources of the Gulf of Alaska region. North Pacific Fishery Management Council, 605 W. 4th Ave., Suite 306, Anchorage, AK 99501.

Wolotira, R. J., Jr., T. M. Sample, S. F. Noel, and C. R. Iten. 1993. Geographic and bathymetric distributions for many commercially important fishes and shellfishes off the west coast of North America, based on research survey and commercial catch data, 1912-1984. U.S. Dep. Commerce, NOAA Tech. Memo. NMFS-AFSC-6, 184 p.

Figure 6.1 Geographic references used in the descriptions and identification of EFH for groundfish in the GOA and BSAI. (See table of contents for map)

Figure 6.2 NMFS management areas for the GOA and BSAI regions. (See table of contents for map)

See table of contents for the following tables:

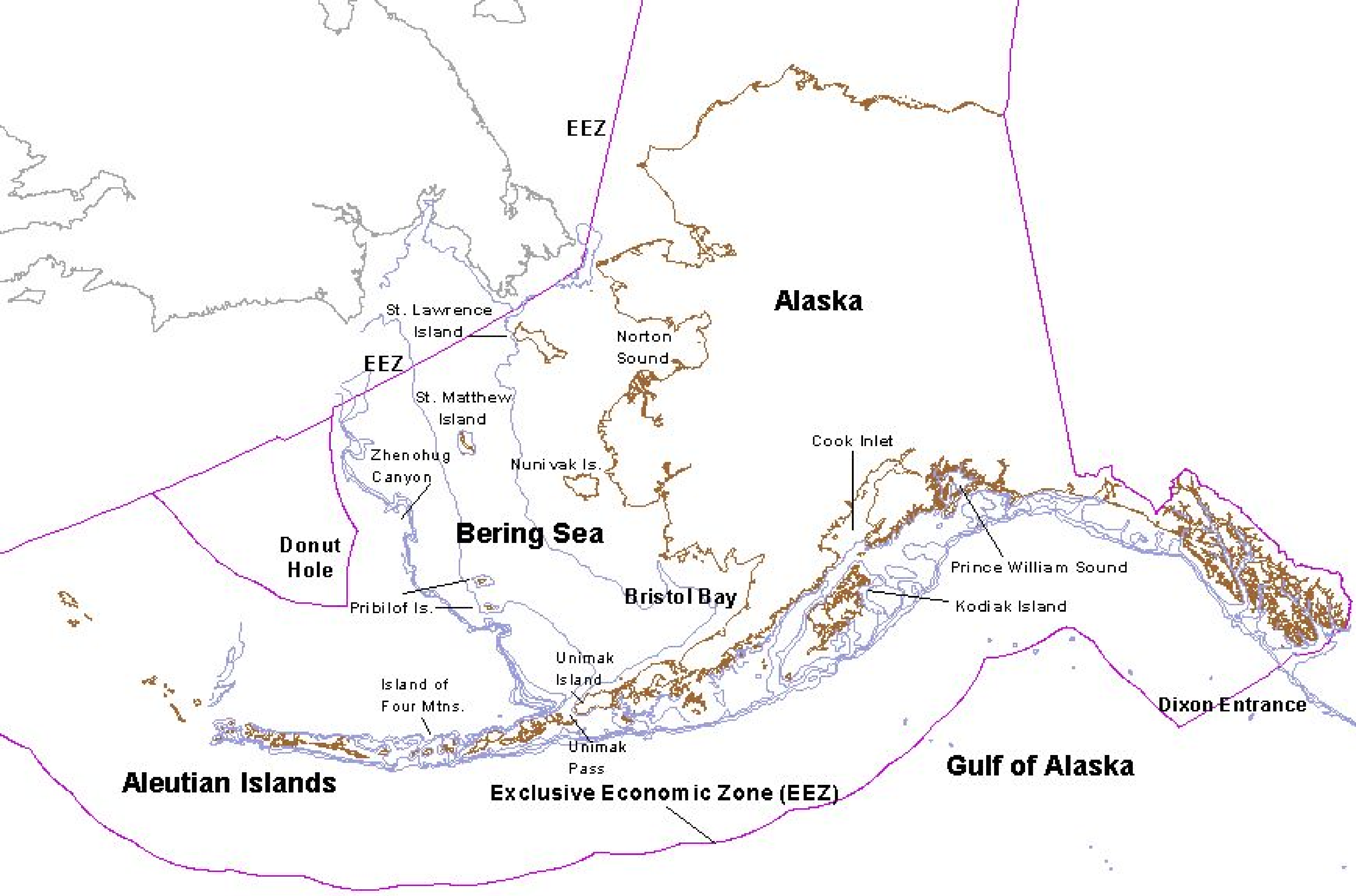
Table 6.1 Summary of habitat associations for groundfish in the BSAI and GOA.

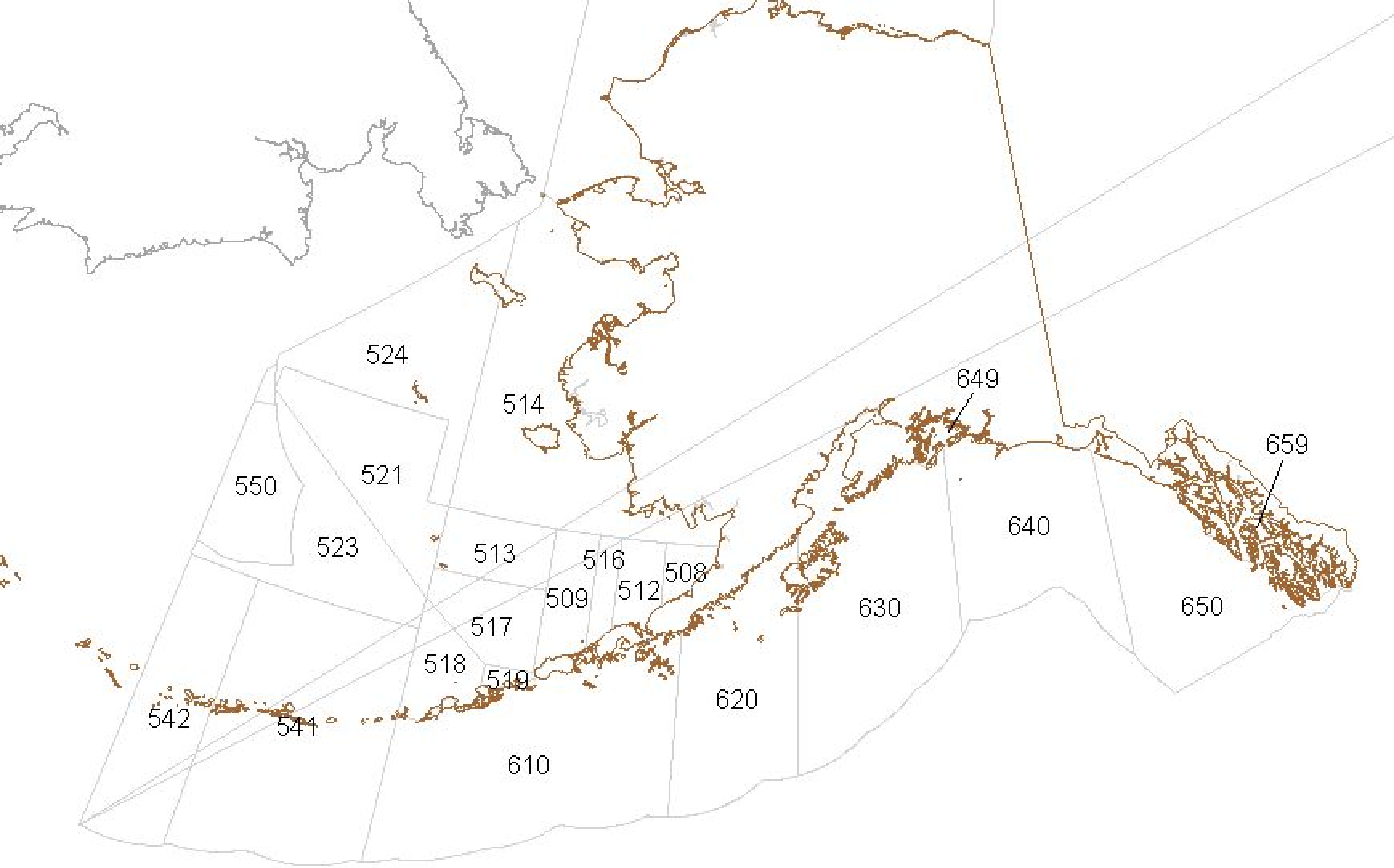
Table 6.2 Summary of biological associations for groundfish in the BSAI and GOA.

Table 6.3 Summary of reproductive traits for groundfish in the BSAI and GOA.

Table 6.4 References Used to Draw Maps for BSAI Groundfish

	References					
Species	Allen and Smith 1988	Fritz et al. In press (a)	Fritz et al. In press (b)	NOAA 1987	NOAA 1990	Wolotira et al. 1993
Walleye pollock	X	X	X	X	X	X
Pacific cod	X	X	X	X	X	X
Yellowfin sole	X	X	X	X		X
Greenland turbot	X	X	X	X		X
Arrowtooth flounder	X	X	X	X	X	X
Rock sole	X	X	X	X		X
Alaska plaice	X	X	X	X		X
Flathead sole	X	X	X	X	X	X
Sablefish	X	X	X		X	X
Pacific ocean perch	X	X	X		X	X
Shortraker-rougheye rockfish	X	X	X			
Northern rockfish	X	X	X			
Dusky rockfish	X	X	X			
Thornyhead rockfish	X	X	X			
Atka mackerel	X	X	X		X	X
Sculpins	X	X	X			
Skates	X	X	X			


EEZ
EEZ
Alaska
St. Lawrence Island
Norton Sound
St. Matthew Island
Zhenohug Canyon
Nunivak Is.
Cook Inlet
Bering Sea
Donut Hole
Prince William Sound
Bristol Bay
Pribilof Is.
Kodiak Island
Unimak Island
Island of Four Mtns.
Dixon Entrance
Unimak Pass
Gulf of Alaska
Aleutian Islands
Exclusive Economic Zone (EEZ)


524
514
521
550
523
513
516
508
509
512
517
518
519
542
541
610
620
630
640
649
659
650

		HABITAT ASSOCIATIONS																														
		Location										Substrate								Vegeta-tion		Pelagic Domain					Oceanography					
	Life Stage/Activity	**Beach (intertidal)**	**Inner Shelf (1-50 m)**	**Middle Shelf (50-100 m)**	**Outer Shelf (100-200 m)**	**Upper Slope (200-1000 m)**	**Lower Slope (>1000m)**	**Basin (> 3000 m)**	**Bay/Estuarine**	**Island pass**	**Not Known**	**Mud/Clay/Silt**	**Sand/Granule**	**Gravel**	**Pebble**	**Cobble**	**Boulder**	**Bedrock**	**Not Applicable**	**Kelp Forest**	**Sea Grasses**	**Near Surface**	**Pelagic**	**Semi-demersal/Semi-pelagic**	**Demersal**	**Not Known**	**Upwelling areas**	**Gyres**	**Thermo/pycnocline**	**Fronts**	**Edges (ice, bathymetric)**	**Life Stage/Activity**
Walleye pollock	A				X			X															X	X			X	X		X	X	A
	J		X	X	X					X									X				X	X				X	X	X		J
	L				X														X				X					X		X		L
	E				X	X		X											X				X					X				E
Pacific cod	A		X	X	X							X	X												X							A
	LJ		X	X	X							X	X												X							LJ
	EJ		X	X								X	X												X							EJ
	L										X								X			X										L
	E		X	X	X							X	X												X							E
Yellowfin sole	A	X	X	X	X				X				X												X						X	A
	LJ		X	X	X				X				X												X							LJ
	EJ		X	X	X				X				X												X							EJ
	L	X	X						X										X				X									L
	E	X							X										X				X									E
Greenland turbot	A				X	X	X					X	X											X	X							A
	LJ		X	X	X	X						X	X											X	X							LJ
	EJ		X	X	X														X							X						EJ
	L		X	X	X														X				X									L
	E			X	X																			X	X							E
Arrowtooth flounder	A		X	X	X	X			X			X	X	X											X						X	A
	LJ		X	X	X	X						X	X	X											X							LJ
	EJ		X	X	X	X						X	X	X											X							EJ
	L		X	X	X				X														X									L
	E		X	X	X																		X									E
Rock sole	A		X	X	X								X	X											X						X	A
	LJ		X	X	X				X				X	X											X							LJ
	EJ		X	X	X				X				X	X											X							EJ
	L		X	X	X																		X									L
	E				X																				X							E
Dover sole	A			X	X	X						X	X												X							A
	LJ		X	X								X	X												X							LJ
	EJ		X	X								X	X												X							EJ
	L		X	X	X	X													X				X									L
	E		X	X	X	X													X				X									E

Table 1. Summary of Habitat associations for Groundfish in the BSAI and GOA.

		HABITAT ASSOCIATIONS																														
		Location										Substrate								Vegeta-tion		Pelagic Domain					Oceanography					
	Life Stage/Activity	Beach (intertidal)	Inner Shelf (1-50 m)	Middle Shelf (50-100 m)	Outer Shelf (100-200 m)	Upper Slope (200-1000 m)	Lower Slope (>1000m)	Basin (> 3000 m)	Bay/Estuarine	Island pass	Not Known	Mud/Clay/Silt	Sand/Granule	Gravel	Pebble	Cobble	Boulder	Bedrock	Not Applicable	Kelp Forest	Sea Grasses	Near Surface	Pelagic	Semi-demersal/Semi-pelagic	Demersal	Not Known	Upwelling areas	Gyres	Thermo/pycnocline	Fronts	Edges (ice, bathymetric)	Life Stage/Activity
Alaska plaice	A		X	X								X	X												X							A
	J		X	X								X	X												X							J
	L		X	X																			X									L
	E		X		X																		X									E
Rex sole	A			X	X	X						X	X	X											X							A
	J		X	X	X							X	X	X											X							J
	L		X	X	X														X				X									L
	E		X	X	X														X				X									E
Flathead sole	A		X	X	X							X	X												X						X	A
	LJ		X	X	X							X	X												X							LJ
	EJ		X	X	X							X	X												X							EJ
	L		X	X	X														X				X									L
	E		X	X	X														X				X									E
Sablefish	A					X	X																		X		X					A
	LJ					X	X																		X		X					LJ
	EJ		X	X	X				X	X									X				X	X	X		X					EJ
	L			X	X	X	X	X											X			X					X					L
	E					X	X	X											X				X				X					E
Pacific Ocean perch	A				X	X								X	X	X								X	X		X					A
	J		X	X	X	X								X	X	X	X						X	X			X					J
	L		X	X	X	X	X	X											X				X				X					L
Shortraker & Rougheye rockfish	A				X	X						X	X	X	X	X	X	X						X								A
	J			X	X																					X						J
	L										X								X							X						L
Northern rockfish	A				X	X										X	X							X								A
	J		X	X	X											X	X							X								J
	L										X								X				X									L
Dusky rockfish	A				X	X								X		X	X							X								A
	J		X	X	X									X		X	X									X						J
	L										X								X				X									L

Table 1. Summary of Habitat associations for Groundfish in the BSAI and GOA.

		HABITAT ASSOCIATIONS																														
		Location										Substrate								Veg.		Pelagic Domain					Oceanography					
	Life Stage/Activity	Beach (intertidal)	Inner Shelf (1-50 m)	Middle Shelf (50-100 m)	Outer Shelf (100-200 m)	Upper Slope (200-1000 m)	Lower Slope (>1000m)	Basin (> 3000 m)	Bay/Estuarine	Island pass	Not Known	Mud/Clay/Silt	Sand/Granule	Gravel	Pebble	Cobble	Boulder	Bedrock	Not Applicable	Kelp Forest	Sea Grasses	Near Surface	Pelagic	Semi-demersal/Semi-pelagic	Demersal	Not Known	Upwelling areas	Gyres	Thermo/pycnocline	Fronts	Edges (ice, bathymetric)	Life Stage/Activity
Yelloweye rockfish	A			X	X	X			X	X				X		X	X								X							A
	J			X	X	X			X	X				X		X									X							J
	L										X			X		X									X							L
Thornyhead rockfish	A			X	X	X	X					X	X	X	X	X	X	X							X							A
	J			X	X	X						X	X	X	X	X	X	X							X							J
	L										X												X									L
	E										X												X									E
Atka mackerel	A		X	X	X					X				X	X	X				X				X						X	X	A
	J										X															X						J
	L										X											X										L
	E		X							X				X	X	X				X					X							E
Squid	A		X	X	X	X	X	X																X			X			X		A
	J		X	X	X	X	X	X											X			X	X				X			X		J
	E					X	X					X	X												X							E
Capelin	A	X	X	X	X								X	X									X	X	X					X	X	A
	J		X	X															X				X							X	X	J
	L		X	X															X			X	X									L
	E	X											X			X									X							E
Eulachon	A			X	X	X			X				X			X							X		X					X		A
	J			X	X	X													X				X							X		J
	L		X																X				X									L
	E								X				X			X									X							E
Sculpins	A	X	X	X	X	X						X	X	X											X							A
	J	X	X	X	X	X						X	X	X											X							J
	L		X	X	X	X													X			X	X									L
	E	X	X	X	X									X	X	X									X							E
Sharks	A		X	X	X	X													X				X		X							A
	J		X	X	X	X													X				X		X							J
	L										X								X													L
Skates	A			X	X	X																			X							A
	J			X	X	X																			X							J
	E			X	X	X																			X							E
Octopus	A		X	X	X	X						X	X	X											X							A
	J		X	X	X	X					X													X								J
	E		X	X	X	X					X			X	X	X									X							E

Table 1. Summary of Habitat associations for Groundfish in the BSAI and GOA.

		BIOLOGICAL ATTRIBUTES																							
		Feeding Type						Movements					Social Behavior				Longevity of Life Stage								
	Life Stage/Activity	**Carnivore**	**Herbivore**	**Omnivore**	**Planktivore**	**Detritivore**	**Not Known**	**Drift With Ocean Conditions**	**Reside in Nursery Areas**	**Alongshore Migrations**	**Inshore/Offshore Migrations**	**Not Known**	**Solitary**	**Schooling**	**Shoaling**	**Not Known**	**1 Day**	**1 - 30 Days**	**1 - 12 Months**	**1 - 5 Years**	**5 - 20 Years**	**20 - 50 Years**	**> 50 Years**	**Not Known**	**Life Stage/Activity**
Walleye pollock	A	X						X						X							X				A
	J	X						X						X						X					J
	L				X			X								X			X						L
	E							X										X							E
Pacific cod	A	X										X		X							X				A
	LJ	X						X								X				X					LJ
	EJ	X						X								X			X						EJ
	L				X			X								X								X	L
	E								X									X							E
Yellowfin sole	A	X									X					X					X				A
	LJ	X										X				X				X					LJ
	EJ	X										X				X				X					EJ
	L				X							X				X			X						L
	E											X				X								X	E
Greenland turbot	A	X									X					X					X				A
	LJ	X										X				X					X				LJ
	EJ						X					X				X				X					EJ
	L				X							X				X			X						L
	E											X				X								X	E
Arrowtooth flounder	A	X									X					X				X					A
	LJ	X										X				X				X					LJ
	EJ	X										X				X				X					EJ
	L				X							X				X			X						L
	E											X				X								X	E
Rock sole	A	X									X					X					X				A
	LJ	X										X				X					X				LJ
	EJ	X										X				X				X					EJ
	L				X							X				X			X						L
	E											X				X								X	E
Dover sole	A	X																			X				A
	LJ	X																		X					LJ
	EJ	X																		X					EJ
	L				X			X								X			X						L
	E											X				X								X	E

Table 2. Summary of Biological associations for Groundfish in the BSAI and GOA.

		BIOLOGICAL ATTRIBUTES																							
		Feeding Type						Movements					Social Behavior				Longevity of Life Stage								
	Life Stage/Activity	Carnivore	Herbivore	Omnivore	Planktivore	Detritivore	Not Known	Drift With Ocean Conditions	Reside in Nursery Areas	Alongshore Migrations	Inshore/Offshore Migrations	Not Known	Solitary	Schooling	Shoaling	Not Known	1 Day	1 - 30 Days	1 - 12 Months	1 - 5 Years	5 - 20 Years	20 - 50 Years	> 50 Years	Not Known	Life Stage/Activity
Alaska plaice	A	X										X				X					X				A
	J	X										X				X					X				J
	L				X							X				X			X						L
	E											X				X								X	E
Rex sole	A	X										X				X				X					A
	J	X										X				X				X					J
	L				X							X				X								X	L
	E											X				X								X	E
Flathead sole	A	X									X					X								X	A
	LJ	X										X				X								X	LJ
	EJ	X										X				X								X	EJ
	L				X			X								X								X	L
	E											X				X								X	E
Sablefish	A	X										X				X						X			A
	LJ	X										X				X				X					LJ
	EJ	X									X					X				X					EJ
	L				X			X								X			X						L
	E							X								X		X							E
Pacific Ocean perch	A	X									X			X									X		A
	J	X										X				X					X				J
	L				X							X				X			X						L
Shortraker/rougheye rockfish	A	X										X				X							X		A
	J	X										X				X								X	J
	L						X					X				X								X	L
Northern rockfish	A	X										X		X									X		A
	J						X					X				X					X				J
	L						X					X				X								X	L
Dusky rockfish	A	X										X				X						X			A
	J						X					X				X								X	J
	L						X					X				X								X	L
Yelloweye rockfish	A	X										X	X										X		A
	J						X					X	X								X				J
	L				X							X				X			X						L
Thornyhead rockfish	A	X										X				X								X	A
	J	X										X				X								X	J
	L						X					X				X			X						L
	E						X					X				X								X	E

Table 2. Summary of Biological associations for Groundfish in the BSAI and GOA.

		BIOLOGICAL ATTRIBUTES																							
		Feeding Type						Movements					Social Behavior				Longevity of Life Stage								
	Life Stage/Activity	Carnivore	Herbivore	Omnivore	Planktivore	Detritivore	Not Known	Drift With Ocean Conditions	Reside in Nursery Areas	Alongshore Migrations	Inshore/Offshore Migrations	Not Known	Solitary	Schooling	Shoaling	Not Known	1 Day	1 - 30 Days	1 - 12 Months	1 - 5 Years	5 - 20 Years	20 - 50 Years	> 50 Years	Not Known	Life Stage/Activity
Atka mackerel	A	X									X			X						X					A
	J	X										X				X				X					J
	L	X										X				X			X						L
	E				X							X				X		X							E
Squid	A	X									X					X				X					A
	J				X							X				X			X						J
	E						X					X				X			X						E
Capelin	A	X									X			X						X					A
	J	X										X				X				X					J
	L				X							X				X			X						L
	E											X				X		X							E
Eulachon	A	X									X			X						X					A
	J	X										X				X				X					J
	L				X							X				X			X						L
	E											X				X		X							E
Sculpins	A	X										X				X								X	A
	J	X										X				X								X	J
	L						X					X				X								X	L
	E						X					X				X								X	E
Sharks	A	X										X				X							X		A
	J	X										X				X								X	J
	L						X					X				X								X	L
	E						X					X				X								X	E
Skates	A	X										X				X								X	A
	J	X										X				X								X	J
	E											X				X								X	E
Octopus	A	X										X				X				X					A
	J				X							X				X								X	J
	E											X				X								X	E

Table 2. Summary of Biological associations for Groundfish in the BSAI and GOA.

	Reproductive Traits																							
	Age at Maturity				Fertilization/Egg Development					Spawning Behavior						Spawning Season								
	Female		Male																					
	50%	100%	50%	100%	External	Internal	Oviparous	Ovoviviparous	Viviparous	Batch Spawner	Broadcast Spawner	Egg Case Deposition	Nest Builder	Egg/Young Guarder	Egg/Young Bearer	Early Spring	Late Spring	Early Summer	Late Summer	Early Fall	Late Fall	Early Winter	Late Winter	Not Known
Walleye pollock	4 yrs		4 yrs		X						X					X								
Pacific cod	5 yrs		5 yrs		X					X						X						X	X	
Yellowfin sole	10.5yrs.				X						X						X	X	X					
Greenland turbot	5-10yrs.				X						X									X	X	X	X	
Arrowtooth flounder	5 yrs		4 yrs		X																			X
Rock sole	9yrs.				X					X						X							X	
Dover sole	33cm				X											X	X					X	X	
Alaska plaice	6-7yrs				X											X								
Rex sole	24cm		16cm		X											X	X	X					X	
Flathead sole					X											X								
Sablefish	65cm		57cm		X						X					X	X							
Pacific ocean perch	10.5 yrs					X			X												X	X		
Shortraker/Rougheye rockfish	20 yrs		20 yrs			X			X								X	X						
Northern rockfish	12.8 yrs					X			X								X	X						
Dusky rockfish						X			X								X	X						
Yelloweye rockfish	22 yrs		22 yrs			X			X								X	X						
Thornyhead rockfish	12 yrs									X						X							X	
Atka mackerel	3 yrs		3 yrs		X								X	X				X	X					
Squid						X											X	X						
Capelin	2 yrs	4 yrs	2 yrs	4 yrs	X						X						X	X	X					
Eulachon	3 yrs	5 yrs	3 yrs	5 yrs	X					X							X							
Sculpins					X	X							X	X								X	X	
Sharks						X		X																
Skates						X	X					X												X
Octopus						X																		X

Table 3. Summary of Reproductive traits for Groundfish in the BSAI and GOA.

Table 6.5 References Used to Draw Maps for GOA Groundfish

Species	References: Allen and Smith 1988	Fritz et al. In press (a)	Fritz et al. In press (b)	NOAA 1990	Wolotira et al. 1993
Walleye pollock	X	X	X	X	X
Pacific cod	X	X	X	X	X
Dover sole	X	X	X	X	X
Yellowfin sole	X	X	X		X
Rock sole	X	X	X		X
Rex sole	X	X	X		X
Flathead sole	X	X	X	X	X
Arrowtooth flounder	X	X	X	X	X
Sablefish	X	X	X	X	X
Pacific ocean perch	X	X	X	X	X
Shortraker-rougheye rockfish	X	X	X		
Northern rockfish	X	X	X		
Dusky rockfish	X	X	X		
Yelloweye rockfish	X	X	X		
Thornyhead rockfish	X	X	X		
Atka mackerel	X	X	X	X	X
Sculpins	X	X	X		
Skates	X	X	X		

EFH Definition for BSAI Walleye Pollock

Eggs(duration 14-25 days) - Level 1
Pelagic waters of the outer continental shelf and upper slope of the eastern Bering Sea from Unimak Island northwest to Zhenchug Canyon. Also in pelagic waters (200-400 m) depth) over basin and lower slope areas in the Aleutian Islands and the Aleutian Basin. These are likely areas of upwelling or have gyres. Spawning occurs in February-April.

Larvae (duration 60 days) - Level 1
Epipelagic waters on the inner, middle, and outer continental shelf and upper slope throughout the eastern Bering Sea, eastern portions of the Aleutian Basin and throughout the Aleutians Islands. Survival is enhanced where food (copepod nauplii and small euphausiids) is concentrated, such as along semi-permanent fronts (mid-shelf front near the 100 m isobath) in the eastern Bering Sea, within ephemeral gyres, and possibly in association with jellyfish.

Juveniles (up to 4 years) - Level 1
Throughout the eastern Bering Sea and the Aleutian Islands both pelagically and on-bottom (no known substrate preferences) throughout the inner, middle, and outer shelf regions. At ages 2 and 3 years, pollock are located off-bottom within the water column, principally in the middle and outer shelf regions northwest of the Pribilof Islands. Ranges of juveniles of strong year-classes have varied from throughout the eastern Bering Sea (1978 year-class) to almost exclusively north of Zhenchug Canyon (1989 year-class). Feeding areas contain pelagic crustaceans such as copepods and euphausiids.

Adults (4+ years old) - Level 2
Meso-pelagic and semi-demersal habitats (no known substrate preferences) along the middle and outer continental shelf in the eastern Bering Sea from the U.S. Russia Convention Line to Unimak Pass and northeast along the Alaska Peninsula and throughout the Aleutian Islands. Also exists pelagically over deep Aleutian basin waters. Feeding areas are those that concentrate pelagic crustaceans (e.g., euphausiids) and juvenile fish (primarily juvenile pollock), such as in upwelling regions along the shelf break or fronts on the middle shelf. Known spawning areas in the eastern Bering Sea are: north of Unimak Island, along the mid-shelf front (100m isobath)between Unimak Island and the Pribilof Islands, south of the Pribilof Islands, and possibly at other areas to the north, particularly at heads of submarine canyons. Known spawning areas in the Aleutian Islands are : over deep waters north of Umnak and Unalaska Islands, the region north of the Islands of Four Mountains, through Amukta Pass to Seguam Island, and north of Kanaga and Tanaga Islands. Pollock may prefer waters of 2-3°C for spawning.

EFH Definition for BSAI Pacific Cod

Eggs(duration 15-20 days) - Level 0_a
Areas of mud and sand on the inner, middle, and outer continental shelf and upper slope throughout the eastern Bering Sea and Aleutian Islands in winter and spring.

Larvae (duration unknown)- Level 0_a
Epipelagic waters throughout the eastern Bering Sea and Aleutian Islands regions in winter and spring.

Early Juveniles (up to 2 years) - Level 0_a
Areas of mud and sand and the water column on the inner and middle continental shelf of the eastern Bering Sea and Aleutian Islands, particularly those with mysids, euphausiids and shrimp.

Late Juveniles (2-4 years) - Level 1
Areas of soft substrate (clay, mud, and sand) and the lower portion of the water column on the inner, middle, and outer continental shelf areas of the eastern Bering Sea and Aleutian Islands, particularly those with mysids, euphausiids, shrimp, pollock, flatfish, crab, and fishery discards.

Adults (4+ years old) - Level 2
Areas of mud and sand along the inner, middle, and outer continental shelf up to 500m along with the lower portion of the water column of the eastern Bering Sea and Aleutian Islands. Spawning occurs in January-May near the bottom across broad areas of the shelf, but predominately along the outer shelf between 100-200 m in the eastern Bering Sea, and throughout the area<200m in the Aleutian Islands. After spawning, the mature population spreads out throughout the shelf in the eastern Bering Sea and Aleutian Islands, but with concentrations along the outer shelf northwest of the Pribilof Islands and along the outer and middle shelf areas northwest of the Alaskan Peninsula and into Bristol Bay. Feeding areas are those containing pollock, flatfish, and crab.

<u>EFH Definition for BSAI Yellowfin Sole</u>

Eggs (duration unknown)- Level 0_a
Pelagic inshore waters of the southeastern Bering Sea shelf from Norton Sound to Bristol Bay in spring and summer.

Larvae (duration 2-3 months) - Level 0_a
Pelagic inshore waters of the southeastern Bering Sea shelf from Norton Sound to Bristol Bay in spring, summer and fall.

Early Juveniles (to 5.5 years old) - Level 0_a
Demersal areas (bottom and lower portion of the water column) on the inner, middle and outer portions of the continental shelf (down to 250 m) and within nearshore bays of the eastern Bering Sea.

Late Juveniles (5.5 - 9 years old) - Level 1
Areas of sandy bottom along with the lower portion of the water column within nearshore bays and on the inner, middle and outer portions of the continental shelf (down to 250 m) of the eastern Bering Sea south of St Matthew Island (approximately 61° N) and in Norton Sound. Feeding areas would be those containing polychaetes, bivalves, amphipods and echiurids.

Adults (9+ years old) - Level 2
Areas of sandy bottom along with the lower portion of the water column on the inner, middle and outer portions of the continental shelf (down to 250 m) of the eastern Bering Sea south of St. Matthew Island (approximately 61° N) and in Norton Sound. Areas of known concentrations vary seasonally. Adult spawning areas in summer (May-August) are located along the inner shelf from Cape Constantine to Cape Peirce, throughout Kuskokwim Bay, and North of Nunivak Island. Summer (June-October) feeding concentrations of adults are located along the inner and middle portions of the shelf from Kuskokwim and Bristol Bays south along the Alaskan Peninsula to Amak Island, and northwest to St. Matthew Island. Feeding areas would be those containing polychaetes, bivalves, amphipods and echiurids. In winter, yellowfin sole adults migrate to deeper waters of the shelf (100-200 m) south of 60°N to the Alaskan Peninsula.

EFH Definition for BSAI Greenland Turbot

Eggs (duration unknown)- Level 0_a
Benthypelagic waters of the outer continental shelf and slope in the eastern Bering Sea and throughout the Aleutian Islands**.**

Larvae (8-9 months) - Level 0_a
Pelagic waters of the outer continental shelf, slope, and adjacent basin in the eastern Bering Sea and throughout the Aleutian Islands.

Early Juveniles (to 4 years old) - Level 0_a
Substrate and lower portion of the water column of the inner, middle and outer portions of the continental shelf and the adjacent upper slope region of the eastern Bering Sea and throughout the Aleutian Islands.

Late Juveniles (4 - 5 years old) - Level 1
Substrate (particularly mud and muddy-sand) and lower portion of the water column of the middle and outer continental shelf and adjacent upper and lower slope regions of the eastern Bering Sea and throughout the Aleutian Islands. Feeding areas would be those containing euphausiids, polychaetes, and small fish.

Adults (5+ years old) - Level 2
Substrate (particularly mud and muddy-sand) and lower portion of the water column of the outer continental shelf and adjacent upper and lower slope regions of the eastern Bering Sea and throughout the Aleutian Islands. Feeding areas would be those containing pollock and small fish.

EFH Definition for BSAI Arrowtooth flounder

Eggs (duration unknown)- Level 0_a
Pelagic waters of the middle and outer continental shelf and slope in the eastern Bering Sea and throughout the Aleutian Islands in winter.

Larvae (duration 2-3 months) - Level 0_a
Pelagic waters of the inner, middle and outer continental shelf and adjacent nearshore bays in the eastern Bering Sea and throughout the Aleutian Islands.

Early Juveniles (to 2 years old) - Level 0_a
Areas of gravel, sand and mud and the associated water column of the inner continental shelf and the adjacent nearshore bays in the eastern Bering Sea and throughout the Aleutian Islands.

Late Juveniles (2 - 4 years old) - Level 1
Areas of gravel, sand and mud and the associated water column of the middle and outer continental shelf and adjacent upper slope regions of the eastern Bering Sea and throughout the Aleutian Islands. Feeding areas would be those containing euphausiids, crustaceans, and small fish.

Adults (4+ years old) - Level 2
Areas of gravel, sand and mud and the associated water column of the middle and outer continental shelf and adjacent upper slope regions of the eastern Bering Sea and throughout the Aleutian Islands. Summer feeding areas on the middle and outer shelf would be those containing gadids, euphausiids, and other fish. Spawning areas in winter are on the outer shelf and upper slope regions.

EFH Definition for BSAI Rock Sole

Eggs (duration unknown) - Level 0_a
Areas of pebbles and sand on the middle and outer continental shelf in the eastern Bering Sea in winter (December-March).

Larvae (duration 2-3 months) - Level 0_a
Pelagic waters of the eastern Bering Sea over the inner, middle and outer continental shelf, the slope, and the Aleutian Basin.

Early Juveniles (to 3.5 years old) - Level 0_a
Inner, middle and outer portions of the continental shelf along with the lower portion of the water column of the eastern Bering Sea south of 61°N and in Norton Sound. Feeding areas would be those containing polychaetes, bivalves, amphipods and crustaceans.

Late Juveniles (3.5 - 8 years old) - Level 1
Areas of pebbles and sand along with the lower portion of the water column within nearshore bays and on the inner, middle and outer portions of the continental shelf of the eastern Bering Sea south of 61° N and in Norton Sound. Feeding areas would be those containing polychaetes, bivalves, amphipods and crustaceans.

Adults (8+ years old) - Level 2
Areas of pebbles and sand along with the lower portion of the water column on the inner, middle and outer portions of the continental shelf of the eastern Bering Sea south of 61° N and in Norton Sound. Areas of known concentrations vary seasonally and include adult spawning areas in winter and feeding areas in summer (May-October), which include Bristol Bay, portions of outer Kuskokwim Bay, north of the Alaskan Peninsula to Unimak Island, and near the Pribilof Islands. Feeding areas would be those containing polychaetes, bivalves, amphipods and crustaceans.

EFH Definition for BSAI Other Flatfish - Alaska plaice

Eggs (duration unknown)-Level 0_a
Pelagic waters of the middle and outer continental shelf of the eastern Bering Sea in spring and early summer.

Larvae (duration 2-4 months)-Level 0_a
Pelagic waters of the inner, middle and outer continental shelf of the eastern Bering Sea in summer and fall.

Early Juveniles (up to 4 years)-Level 0_a
Substrate (particularly areas of sand and mud) and lower portion of the water column on the inner and middle continental shelf of the eastern Bering Sea.

Late Juveniles (4-7 years)-Level 1
Substrate (particularly areas of sand and mud) and lower portion of the water column on the inner, middle and outer continental shelf of the eastern Bering Sea. Feeding areas will be those containing polychaetes, amphipods, and echiurids. With increasing age, plaice overwinter near the edge of the shelf, and return to the middle and inner shelf for feeding in spring, summer and fall.

Adults (7+ years)- Level 2
Substrate (particularly areas of sand and mud) and lower portion of the water column on the inner, middle and outer continental shelf of the eastern Bering Sea. Feeding areas will be those containing polychaetes, amphipods, and echiurids. Overwinters near the edge of the shelf in the southeastern Bering Sea from the

Pribilof islands to Unimak Island and north along the Alaskan peninsula. Occurs across broad areas of the middle and inner shelf on summer and fall.

EFH Definition for BSAI Flathead Sole

Eggs (duration unknown)- Level 0_a
Pelagic waters of the middle and outer portions of the southeastern Bering Sea shelf, adjacent slope and basin waters, and throughout the Aleutian Islands in winter and early spring.

Larvae (duration unknown)- Level 0_a
Pelagic waters of the inner, middle, and outer portions of the southeastern Bering Sea shelf, adjacent slope and basin waters, and throughout the Aleutian Islands in spring and summer.

Early Juveniles (to 2 years old) - Level 0_a
Bottom substrate and lower water column on the inner, middle and outer portions of the southeastern Bering Sea shelf and throughout the Aleutians Islands.

Late Juveniles (2 - 3 years old) - Level 1
Bottom substrate (particularly sand and mud) and lower portion of the water column on the inner, middle, and outer portions of the southeastern Bering Sea shelf south of 61°N and throughout the Aleutian Islands. Feeding areas would be those containing polychaetes, bivalves, ophiuroids, pollock, small tanner crab and other crustaceans.

Adults (3+ years old) - Level 2
Bottom substrate (particularly sand and mud) and lower portion of the water column on the inner, middle, and outer portions of the southeastern Bering Sea shelf south of 61°N and throughout the Aleutian Islands. Feeding areas, primarily on the inner, middle and outer shelf in spring, summer and fall, are those containing polychaetes, bivalves, ophiuroids, pollock, small tanner crab and other crustaceans. Spawning areas in winter and early spring are located primarily on the outer shelf.

EFH definition for BSAI Sablefish

Eggs (duration 14-20 days)- Level 0_a
Pelagic waters of the upper and lower slope, and basin areas from 200-3000 m from late winter to early spring (December-April) in the eastern Bering Sea and Aleutian Islands.

Larvae (duration up to 3 months)-Level 0_a
Epipelagic waters of the middle and outer continental shelf, the slope and basin areas in the eastern Bering Sea and Aleutian Islands during late spring-early summer months (April - July).

Early Juveniles (up to 2 years)- Level 0_a
Pelagic waters, during first summer, along the outer, middle, and inner continental shelf of the eastern Bering Sea and Aleutian Islands. Areas of soft-bottom in nearshore bays and island passes after the first summer until end of second summer.

Late Juveniles (2-5 years)- Level 1
Areas of soft bottom deeper than 200m associated with the continental slope and deep shelf gulleys and fjords (presumably within the lower portion of the water column) of the eastern Bering Sea and Aleutian Islands. Feeding areas are those containing mesopelagic and benthic fishes, benthic invertebrates and jellyfish.

Adults (5+years)- Level 2
Areas of soft bottom deeper than 200m (presumably within the lower portion of the water column) associated with the continental slope and deep shelf gulleys in the eastern Bering Sea and Aleutian Islands. Feeding areas would be those containing mesopelagic and benthic fishes, benthic invertebrates and jellyfish. A large portion of the adult diet is comprised of gadid fishes mainly pollock.

EFH definition for BSAI Pacific Ocean Perch

Eggs (internal incubation, ~90days) No EFH definition determined.
Internal fertilization and incubation. Incubation is assumed to occur during the winter months.

Larvae (duration 60-180 days)- Level 0_a
Pelagic waters of the inner, middle, and outer continental shelf, the upper and lower slope and the basin areas of the Bering Sea and Aleutian Islands, during the spring and summer months.

Early Juveniles (larval stage to 3 years) - Level 0_a
Initially pelagic, then demersal in very rocky areas of the inner continental shelf of the Bering Sea and Aleutian Islands. Includes the water column.

Late Juveniles (3 to 10 years) - Level 1
Areas of cobble, gravel, mud, and sand along the inner, middle, and outer continental shelf and upper slope areas, shallower than adults, and the middle and lower portions of the water column of the Bering Sea and Aleutian Islands Regions. Feeding areas are those containing euphausiids.

Adults (10+ years)- Level 1
Areas of cobble, gravel, mud, and sand along the outer continental shelf and upper slope areas and middle and lower portions oft the water column of the Bering Sea and Aleutian Islands. Feeding areas are those containing euphausiids. Areas of high concentrations tend to vary seasonally and may be related to spawning behavior. In summer, adults inhabit shallower depths (180-250m) and in the fall they migrate farther offshore (300-420m).

EFH definition for BSAI POP complex, Shortraker and Rougheye rockfish

Eggs - No EFH definition determined.
Internal fertilization and incubation.

Larvae (duration unknown)- Level 0_b
Epipelagic waters of the inner, middle, and outer continental shelf, the upper and lower slope and the basin areas of the Bering Sea and Aleutian Islands, during the spring and summer months.

Early Juveniles - Level $0_{a\text{-}b}$
Pelagic waters and substrate on the entire continental shelf of the Bering Sea and Aleutian Islands Regions.

Late Juveniles - Level 0_b and level 1
Areas shallower than adult along the continental shelf of the Bering Sea and Aleutian Islands Regions. Juvenile shortraker rockfish have been only rarely seen.

Adults (15+ years)-Level 1
Areas of mud, sand, rock, cobble, and gravel and the lower portion of the water column on the outer continental shelf and upper slope of the Bering Sea and Aleutian Islands. Fishery concentrations at 100-500 m. Feeding areas would be those areas where shrimps, squid and myctophids occur.

<u>EFH definition for BSAI POP complex, Northern rockfish</u>

Eggs- No EFH definition determined.
Internal fertilization and incubation.

Larvae- Level 0_b
Pelagic waters of the inner, middle, and outer continental shelf, the upper and lower slope and the basin areas extending to the seaward boundary of the EEZ of the Bering Sea and Aleutian Islands, during the spring and summer months.

Early juveniles (up to 25cm)-Level 0_b
Pelagic waters and substrate of the inner, middle, and outer continental shelf of the Bering Sea and Aleutian Islands.

Late Juveniles (greater than 25 cm)-Level 1
Areas of cobble and rock along the shallower regions (relative to adults) of the outer continental shelf of the Bering Sea and Aleutian Islands.

Adults (13+years)- Level 1
Areas of cobble and rock along the outer continental slope and upper slope regions and the middle and lower portions of the water column of the Bering Sea and Aleutian Islands. Areas of relatively shallow banks of the outer continental shelf have been found to have concentrated populations.

<u>EFH definition for BSAI Other rockfish, Dusky rockfish</u>

Eggs-No EFH definition determined.
Internal fertilization and incubation.

Larvae- Level 0_b
Pelagic waters of the inner, middle, and outer continental shelf, the upper and lower slope and the basin areas extending to the seaward boundary of the EEZ of the Bering Sea and Aleutian Islands, during the spring and summer months.

Early juveniles (up to 25cm)-Level 0_b
Pelagic waters of the inner, middle, and outer continental shelf of the Bering Sea and Aleutian Islands.

Juveniles (greater than 25cm)- Level 0_a
Areas of cobble, rock and gravel and the water column along the inner, middle, and outer continental shelf of the Bering Sea and Aleutian Islands..

Adults (up to 50 years) -Level 1
Areas of cobble, rock and gravel along the outer continental shelf and upper slope region and the middle and lower portions of the water column of the Bering Sea and Aleutian Islands. Feeding areas are those containing euphausiids.

EFH definition for BSAI Other rockfish, Thornyhead rockfish

Eggs- Level 0_a
Pelagic waters of the Bering Sea and Aleutian Islands during the late winter and early spring.

Larvae (duration <15 months)- Level 0_a
Pelagic waters of the Bering Sea and Aleutian Islands.

Juveniles (> 15 months)- Level 0_a
Areas of mud, sand, rock, cobble, and gravel and the lower portion of the water column along the middle and outer continental shelf and upper slope of the Bering Sea and Aleutian Islands.

Adults (12+ years)- Level 1
Areas of mud, sand, rock, cobble, and gravel and the lower portion of the water column along the middle and outer continental shelf and upper and lower slope of the Bering Sea and Aleutian Islands. Feeding areas are those containing shrimp, fish (cottids), and small crabs.

EFH Definition for BSAI Atka mackerel

Eggs (duration 1-1.5 months)-Level 0_a
Areas of gravel, rock and kelp in shallow water in island passes, nearshore, and on the inner continental shelf in the Aleutian Islands and south eastern Bering Sea in areas of swift current in summer.

Larvae (duration 1.5-6 months) -Level 0_a
Epipelagic waters of the outer continental shelf of the southeastern Bering Sea and Aleutian Islands, the Aleutian Basin (to the edge of the EEZ), and in the adjacent North Pacific Ocean (to the edge of the EEZ) in fall and winter.

Juveniles (up to 3 years)- Level 0_b
Unknown habitat association; assumed to settle near areas inhabited by adults, but have not been observed in fishery or surveys.

Adults (3+ years)-Level 2
Areas of gravel, rock and kelp on the inner, middle and outer portions of the shelf in the Aleutian Islands and the entire water column to the surface. Areas of gravel and rock on the outer portion of the shelf in the SE Bering Sea and extending nearshore near the Pribilof Islands, including the entire water column. Feeding areas are those containing copepods, euphausiids and meso-pelagic fish (myctophids). Spawning occurs in nearshore (inner shelf and in island passes) rocky areas and in kelp in shallow waters in summer. Move to offshore deeper areas nearby in winter. Perform diurnal/tidal movements between demersal and pelagic areas.

EFH Definition for BSAI Other species- Sculpins

Eggs - Level 0_a
All substrates on the inner, middle and outer continental shelf of the eastern Bering Sea and Aleutian Islands. Some species deposit eggs in rocky shallow waters near shore.

Larvae- Level 0_a
Pelagic waters of the inner, middle and outer continental shelf and slope of the eastern Bering Sea and Aleutian Islands, predominately over the inner and middle shelf.

Juveniles - Level 0_a
Broad range of demersal habitats from intertidal pools, all shelf substrates (mud, sand, gravel, etc.) and rocky areas of the upper slope of the eastern Bering Sea and Aleutian Islands.

Adults - Level 1
Broad range of demersal habitats from intertidal pools, all shelf substrates (mud, sand, gravel, etc.) and rocky areas of the upper slope of the eastern Bering Sea and Aleutian Islands.

<u>EFH Definition for BSAI Other Species -Skates</u>

Eggs-Level 0_a
All bottom substrates of the slope and across the shelf throughout the eastern Bering Sea and Aleutian Islands.

Larvae- No EFH definition determined.
Not applicable (no larval stage)

Juveniles-Level 0_a
Broad range of substrate types (mud, sand, gravel, and rock) and the water column on the shelf and the upper slope of the eastern Bering Sea and Aleutian Islands.

Adults- Level 1
Broad range of substrate types (mud, sand, gravel, and rock) and the lower portion of the water column on the shelf and the upper slope of the eastern Bering Sea and Aleutian Islands.

<u>EFH Definition for BSAI Other Species -Sharks</u>

Eggs- No EFH definition determined.
Not applicable (most are oviparous)

Larvae- No EFH definition determined.
Not applicable (no larval stage)

Juveniles and Adults-Level 0_a
All waters and substrate types in the inner, middle and outer continental shelf and slope of the Bering Sea and Aleutian Islands.

<u>EFH Definition for BSAI Other Species -Octopus</u>

Eggs-Level 0_a
All bottom substrates of the shelf throughout the eastern Bering Sea and Aleutian Islands.

Larvae- No EFH definition determined.
Not applicable (no larval stage)

Juveniles and Adults-Level 0_a
Broad range of substrate types (mostly rock, gravel, and sand) and the lower portion of the water column on the shelf and the upper slope of the eastern Bering Sea and Aleutian Islands. Feeding areas are those containing crustaceans and molluscs.

EFH Definition for BSAI Squid - Red Squid

Eggs-Level 0_a
Areas of mud and sand on the upper and lower slope throughout the eastern Bering Sea and Aleutian Islands.

Larvae- No EFH definition determined.
Not applicable (no larval stage)

Juveniles and Adults-Level 0_a
Pelagic waters of the shelf, slope and basin to the seaward edge of the EEZ in the eastern Bering Sea and Aleutian Islands. Feeding areas are those containing euphausiids, shrimp, forage fish, and other cephalopods.

EFH Definition for BSAI Forage fish complex, Eulachon

Eggs (duration 30-40 days) - Level 0_a
Bottom substrates of sand, gravel and cobble in rivers during April-June.

Larvae (duration 1-2 months) - Level 0_a
Pelagic waters of the inner continental shelf throughout the eastern Bering Sea.

Juveniles (to 3 years of age) - Level 0_a
Pelagic waters of the middle and outer continental shelf and upper slope throughout the eastern Bering Sea.

Adults (3+ years)- Level 0_a
Pelagic waters of the middle to outer continental shelf and upper slope throughout the eastern Bering Sea for non-spawning fishes (July-April). Feeding areas are those containing euphausiids and copepods. Rivers during spawning (April-June).

EFH Definition for BSAI Forage fish complex, Capelin

Eggs (duration 2-3 weeks) - Level 0_a
Sand and cobble intertidal beaches down to 10 m depth along the shores of the eastern Bering Sea in Bristol Bay, Norton Sound, and along the northern shore of the Alaskan Peninsula during May-August.

Larvae (duration 4-8 months) - Level 0_a
Epipelagic waters of the inner and middle continental shelf throughout the eastern Bering Sea.

Juveniles (1-2 yrs)- Level 0_a
Pelagic waters of the inner and middle continental shelf throughout the eastern Bering Sea. May be associated with fronts and ice edges in winter.

Adults(2+ yrs)- Level 0_a
Pelagic waters of the inner, middle and outer continental shelf throughout the eastern Bering Sea during their non-spawning cycle (September-April). Populations associated with fronts and the ice edge formed in winter. Intertidal beaches of sand and cobble down to 10 m depth during spawning (May-August).

EFH Definition for BSAI Forage fish complex, Sand lance

Eggs (3-6 weeks) - Level 0_a
Bottom substrate of sand to sandy gravel along the inner continental shelf throughout the eastern Bering Sea and the Aleutians Islands.

Larvae (100-131 days) - Level 0_a
Pelagic and neustonic waters along the inner continental shelf throughout the eastern Bering Sea and the Aleutians Islands.

Juveniles - Level 0_a
Soft bottom substrates (sand, mud) and the entire water column of the inner and middle continental shelf throughout the eastern Bering Sea and the Aleutians Islands. Feeding areas contain zooplankton, calanoid copepods, mysid shrimps crustacean larvae, gammarid amphipods and chaetognaths.

Adults- Level 0_a
Soft bottom substrates (sand, mud) and the entire water column of the inner and middle continental shelf throughout the eastern Bering Sea and the Aleutians Islands. Feeding areas contain zooplankton, calanoid copepods, mysid shrimps crustacean larvae, gammarid amphipods and chaetognaths.

EFH Definition for BSAI Forage fish complex, Myctophids and Bathylagids

Eggs - Level 0_c - No EFH definition determined
No information available at this time.

Larvae - Level 0_c - No EFH definition determined
No information available at this time.

Juveniles - Level 0_a
Pelagic waters ranging from near surface to lower portion of water column of the slope and basin regions throughout the eastern Bering Sea, the Aleutians Islands, and to the seaward extent of the EEZ in the Bering Sea and North Pacific Ocean.

Adults- Level 0_a
Pelagic waters ranging from near surface to lower portion of water column of the slope and basin regions throughout the eastern Bering Sea, the Aleutians Islands, and to the seaward extent of the EEZ in the Bering Sea and North Pacific Ocean.

EFH Definition for BSAI Forage fish complex, Sand fish

Eggs - Level 0_a
Egg masses attached to rock in nearshore areas throughout the eastern Bering Sea and the Aleutians Islands.

Larvae - Level 0_c - No EFH definition determined
No information available at this time.

Juveniles - Level 0_a
Bottom substrates of mud and sand of the inner continental shelf throughout the eastern Bering Sea and the Aleutians Islands.

Adults- Level 0_a
Bottom substrates of mud and sand of the inner continental shelf throughout the eastern Bering Sea and the Aleutians Islands.

<u>EFH Definition for BSAI Forage fish complex, Euphausiids</u>

Eggs - Level 0_a
Neustonic waters throughout the eastern Bering Sea, the Aleutians Islands, and to the seaward extent of the EEZ in the Bering Sea and North Pacific Ocean in spring.

Larvae - Level 0_a
Epipelagic waters throughout the eastern Bering Sea, the Aleutians Islands, and to the seaward extent of the EEZ in the Bering Sea and North Pacific Ocean in spring.

Juveniles - Level 0_a
Pelagic waters throughout the eastern Bering Sea, the Aleutians Islands and to the seaward extent of the EEZ in the Bering Sea and North Pacific Ocean. Dense populations are associated with upwelling or nutrient-rich areas, such as the edge of the continental shelf, heads of submarine canyons, edges of gullies on the continental shelf, in island passes along the Aleutian Islands and over submerged seamounts.

Adults- Level 0_a
Pelagic waters throughout the eastern Bering Sea, the Aleutians Islands and to the seaward extent of the EEZ in the Bering Sea and North Pacific Ocean. Dense populations are associated with upwelling or nutrient-rich areas, such as the edge of the continental shelf, heads of submarine canyons, edges of gullies on the continental shelf, in island passes along the Aleutian Islands and over submerged seamounts.

<u>EFH Definition for BSAI Forage fish complex, Pholids and Stichaeids</u>

Eggs - Level 0_c - No EFH definition determined
No information available at this time.

Larvae - Level 0_c - No EFH definition determined
No information available at this time.

Juveniles - Level 0_a
Intertidal to demersal waters of the inner continental shelf with mud substrate throughout the eastern Bering Sea and the Aleutians Islands. Certain species are associated with vegetation such as eelgrass and kelp.

Adults- Level 0_a
Intertidal to demersal waters of the inner continental shelf with mud substrate throughout the eastern Bering Sea and the Aleutians Islands. Certain species are associated with vegetation such as eelgrass and kelp.

<u>EFH Definition for BSAI Forage fish complex, Gonostomatids</u>

Eggs - Level 0_c - No EFH definition determined
No information is available at this time.

Larvae - Level 0_c - No EFH definition determined
No information is available at this time.

Juveniles - Level 0_c - No EFH definition determined
No information is available at this time.

Adults- Level 0_a
Bathypelagic waters throughout the eastern Bering Sea, Aleutians Islands, and to the seaward extent of the EEZ in the Bering Sea and North Pacific Ocean.

See table of contents for the following maps:

Walleye Pollock (eggs)

Walleye Pollock (larvae)

Walleye Pollock (juveniles)

Walleye Pollock (adults)

Pacific Cod (adults and late juveniles)

Yellowfin Sole (adults and late juveniles)

Greenland Turbot (adults and late juveniles)

Arrowtooth Flounder (adults and late juveniles)

Rock Sole (adults and late juveniles)

Alaska Plaice (adults and late juveniles)

Flathead Sole (adults and late juveniles)

Sablefish (adults and late juveniles)

Pacific Ocean Perch (adults and late juveniles)

Shortraker and Rougheye Rockfish (adults and late juveniles)

Northern Rockfish (adults and late juveniles)

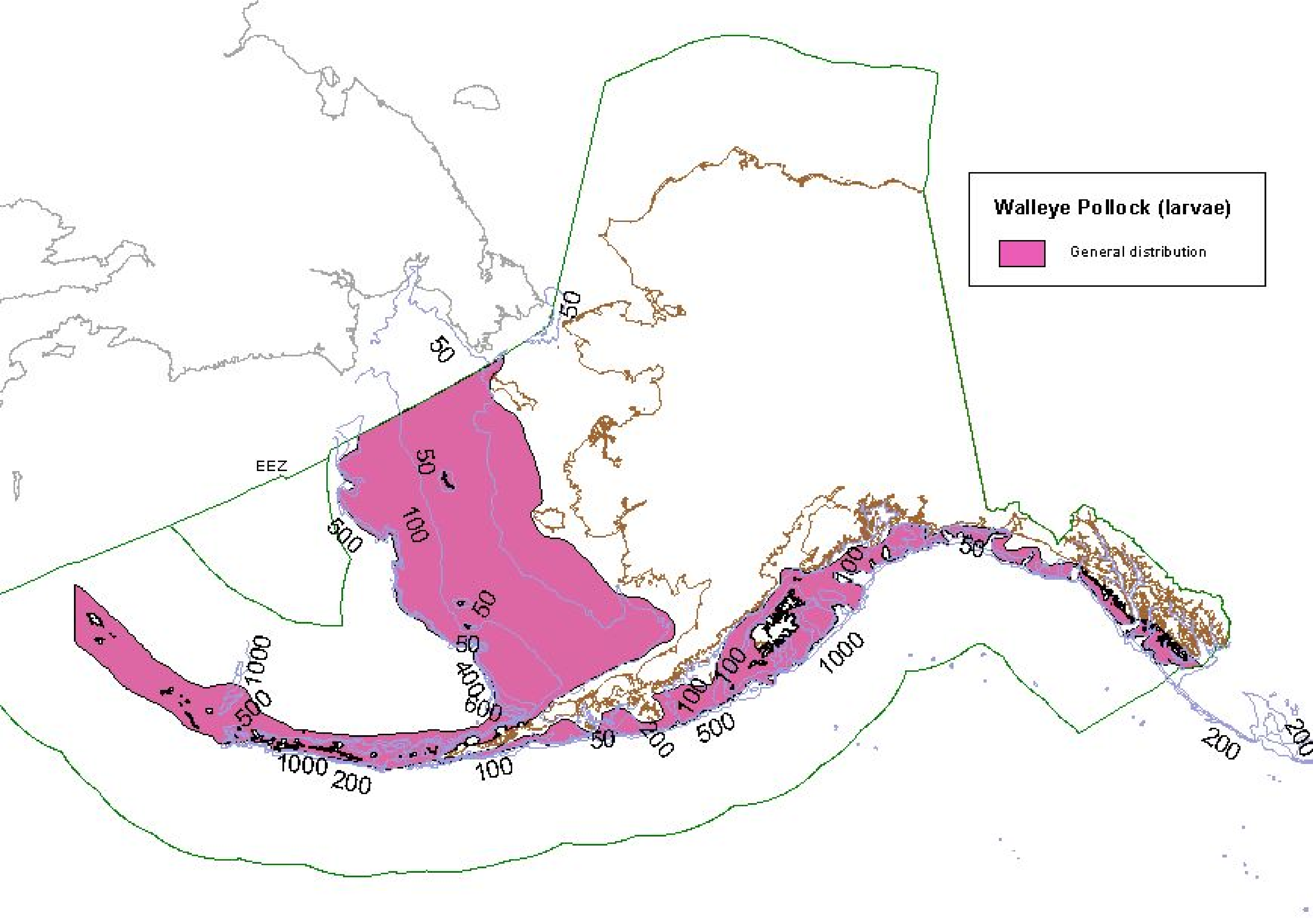
Dusky Rockfish (adults and late juveniles)

Thornyhead Rockfish (adults and late juveniles)

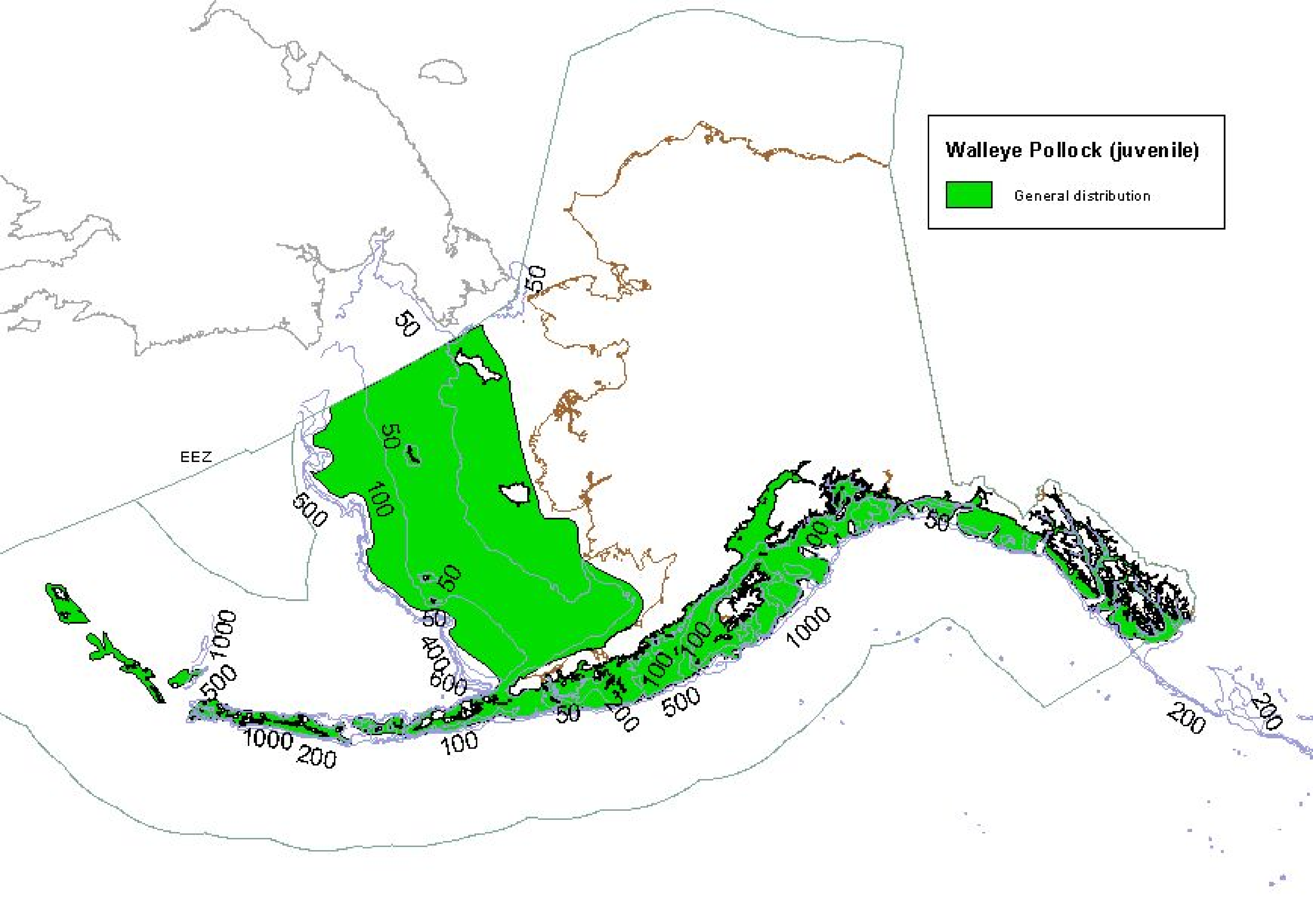
Atka Mackerel (adults and late juveniles)

Sculpins spp. (adults and late juveniles)

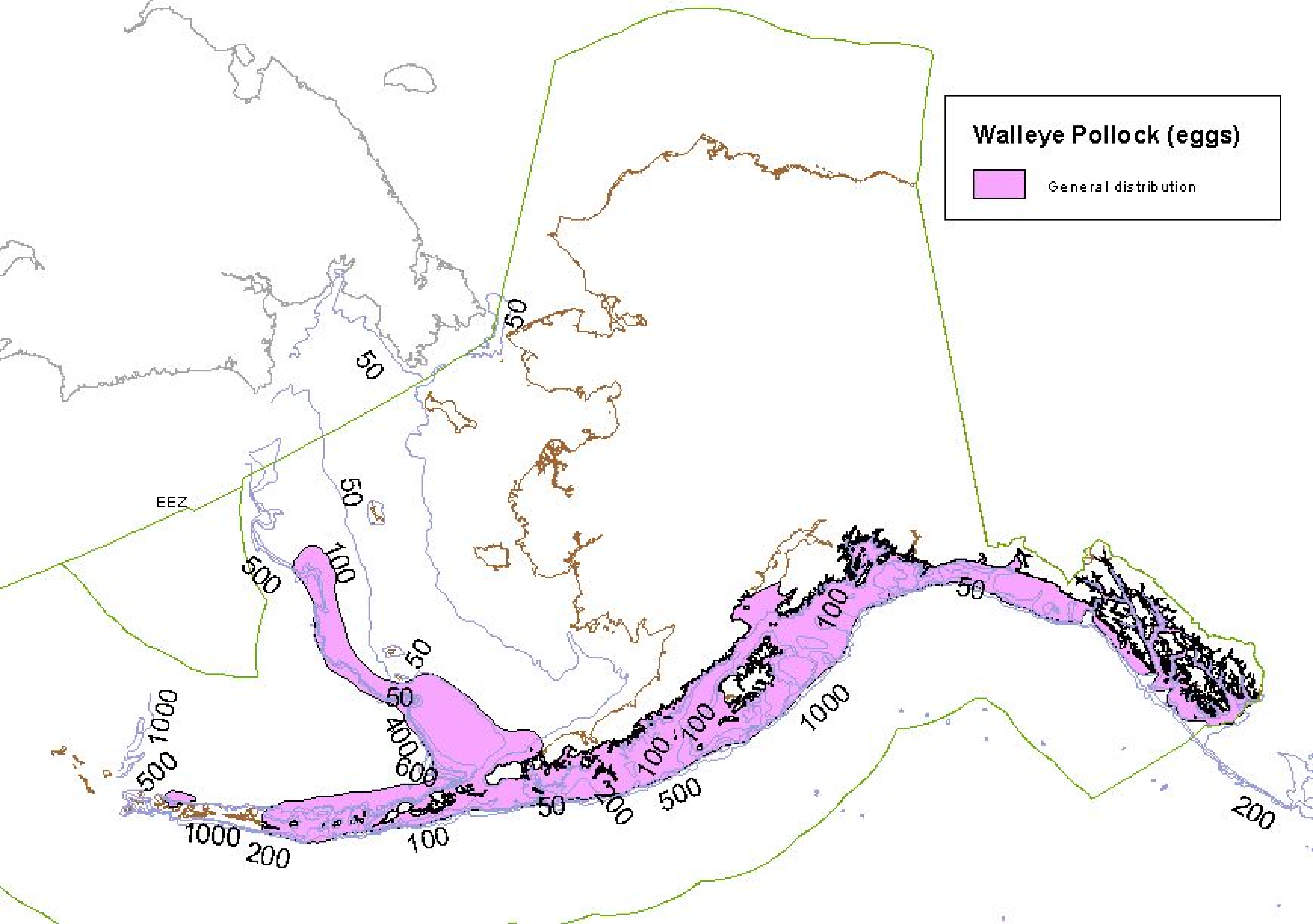
Skates spp. (adults and late juveniles)



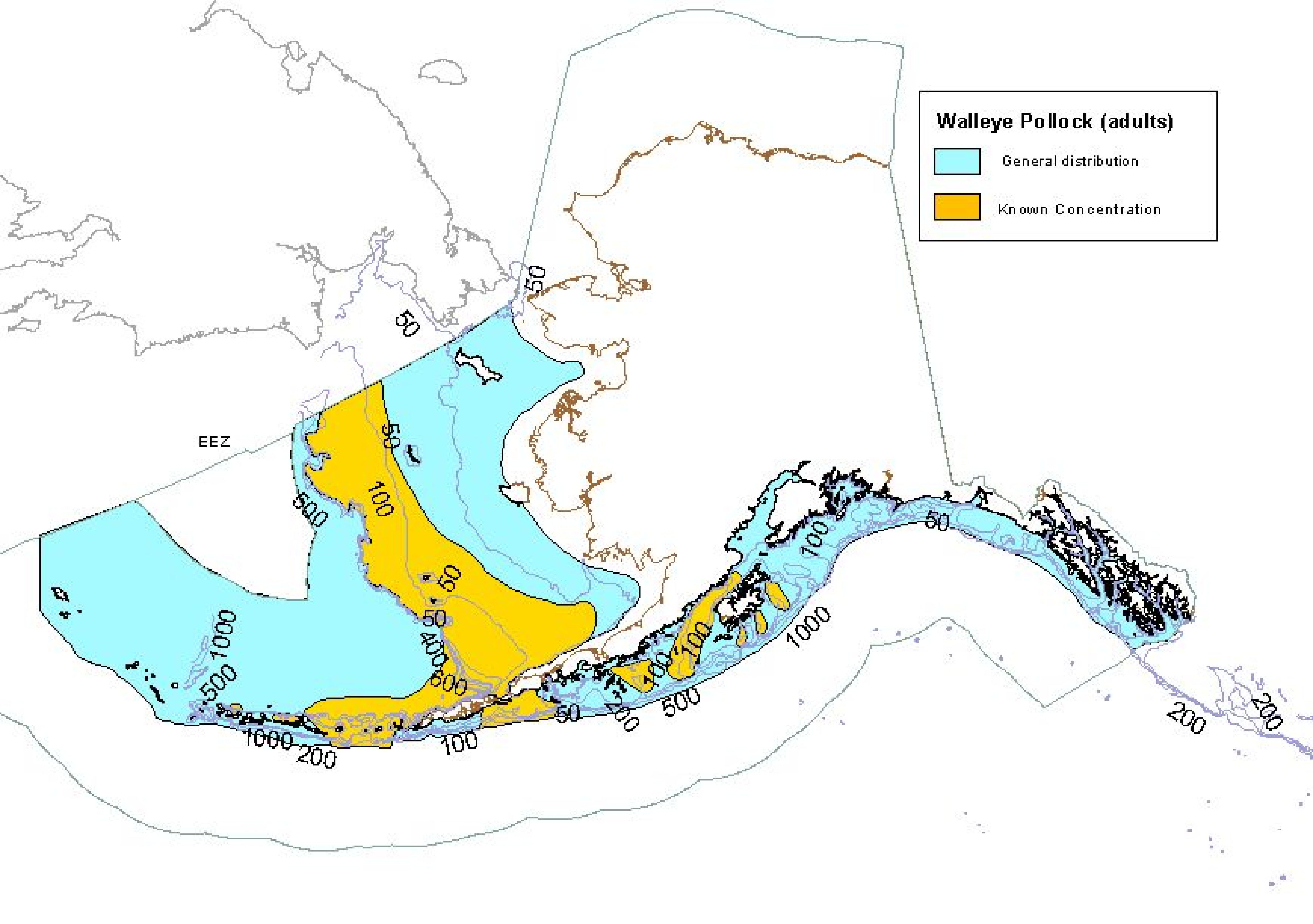
Walleye Pollock (larvae)
General distribution
EEZ
50
100
500
1000
200
400
600

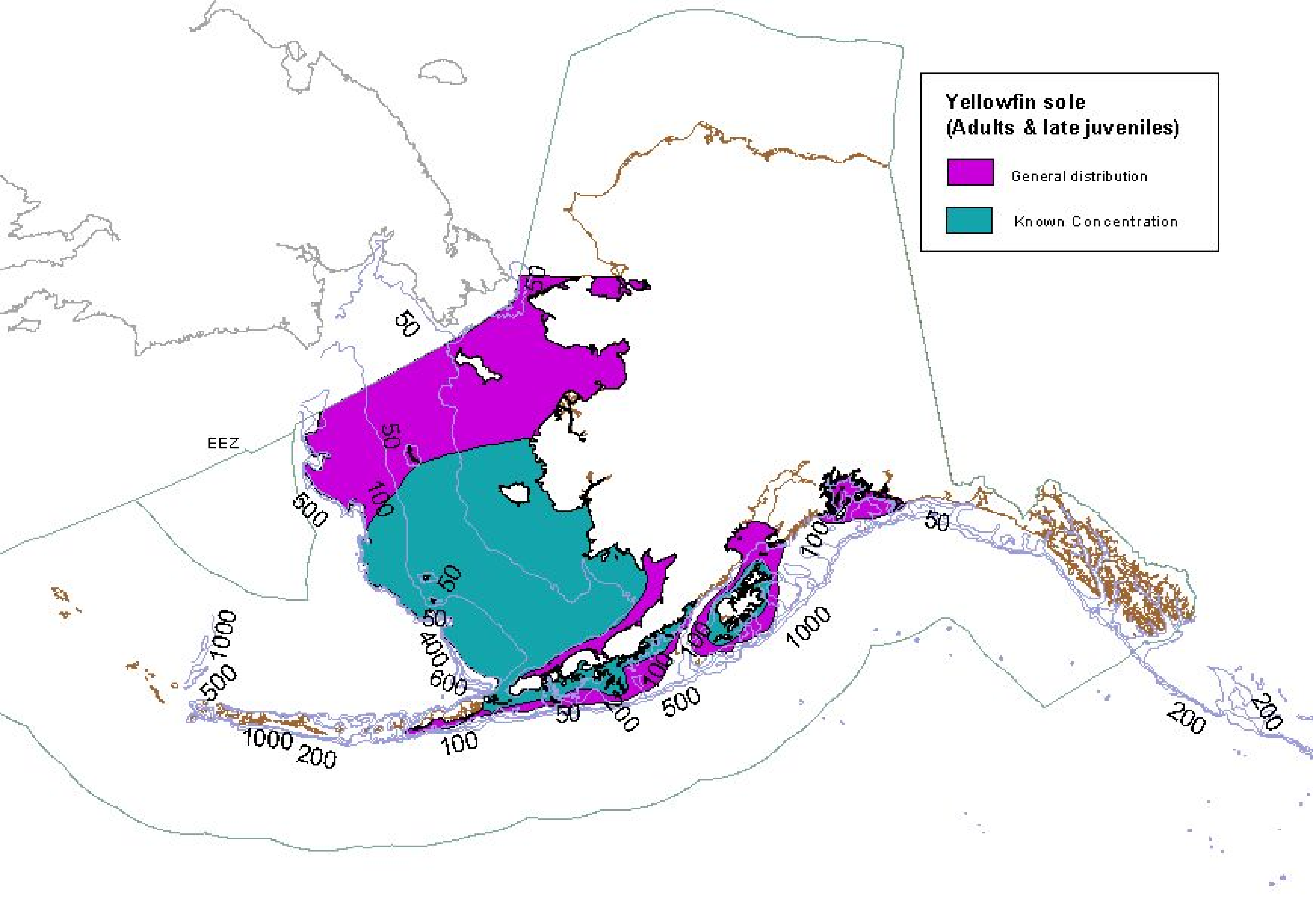


Walleye Pollock (juvenile)
General distribution
EEZ
50
100
200
400
500
600
1000

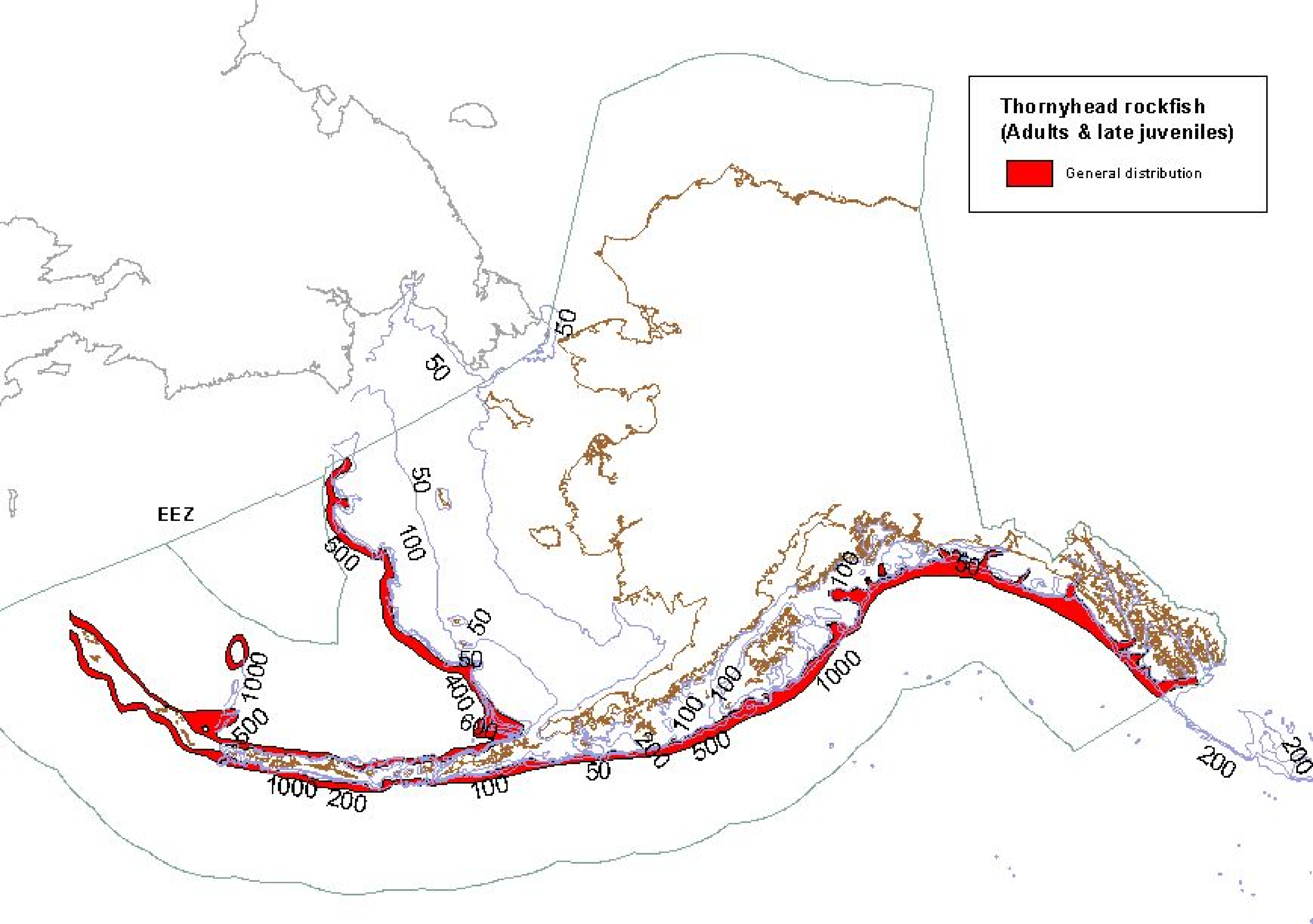


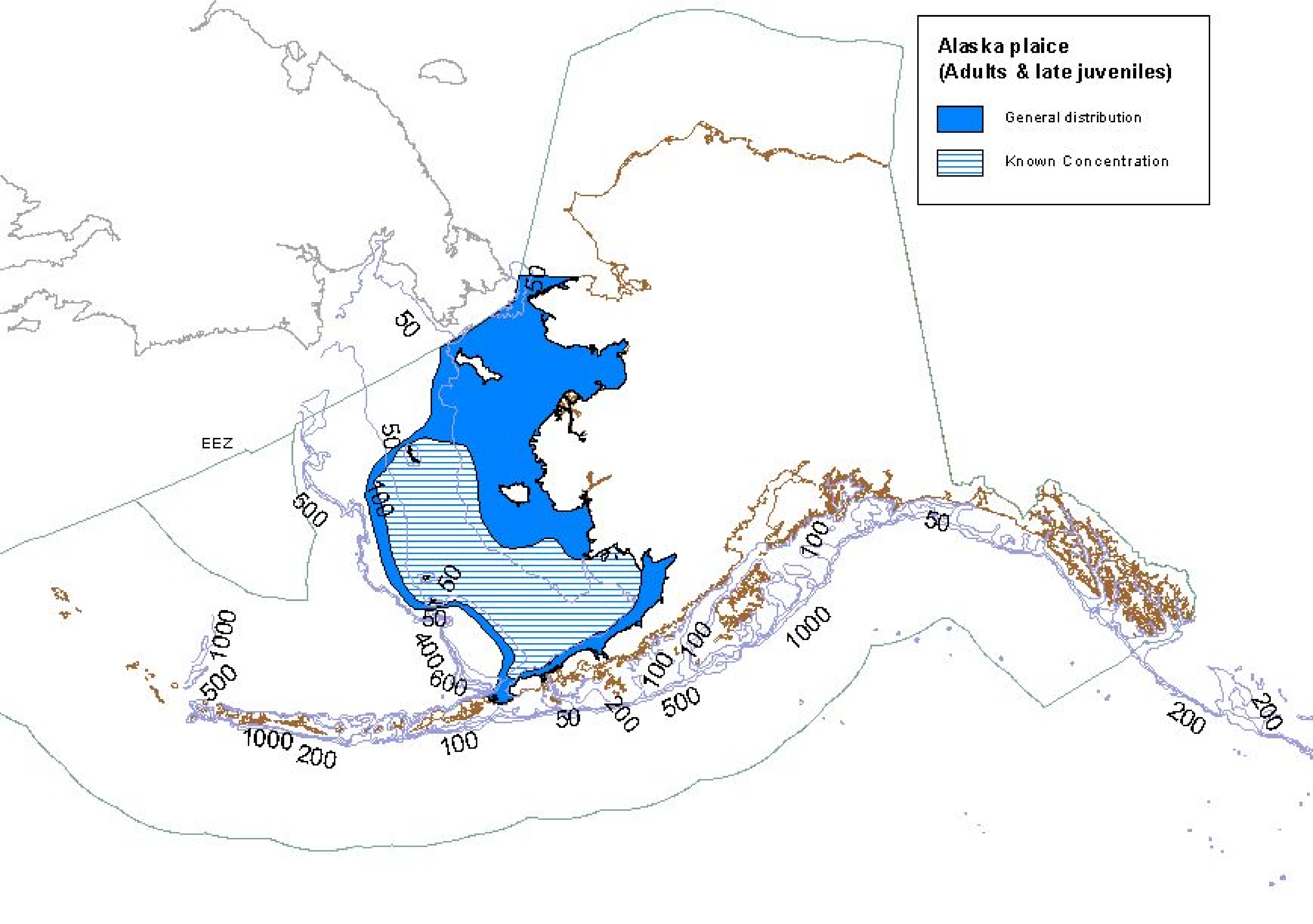
Walleye Pollock (eggs)
General distribution
EEZ
50
50
50
50
50
50
50
100
100
100
100
500
500
500
1000
1000
1000
200
200
200
400
600
100

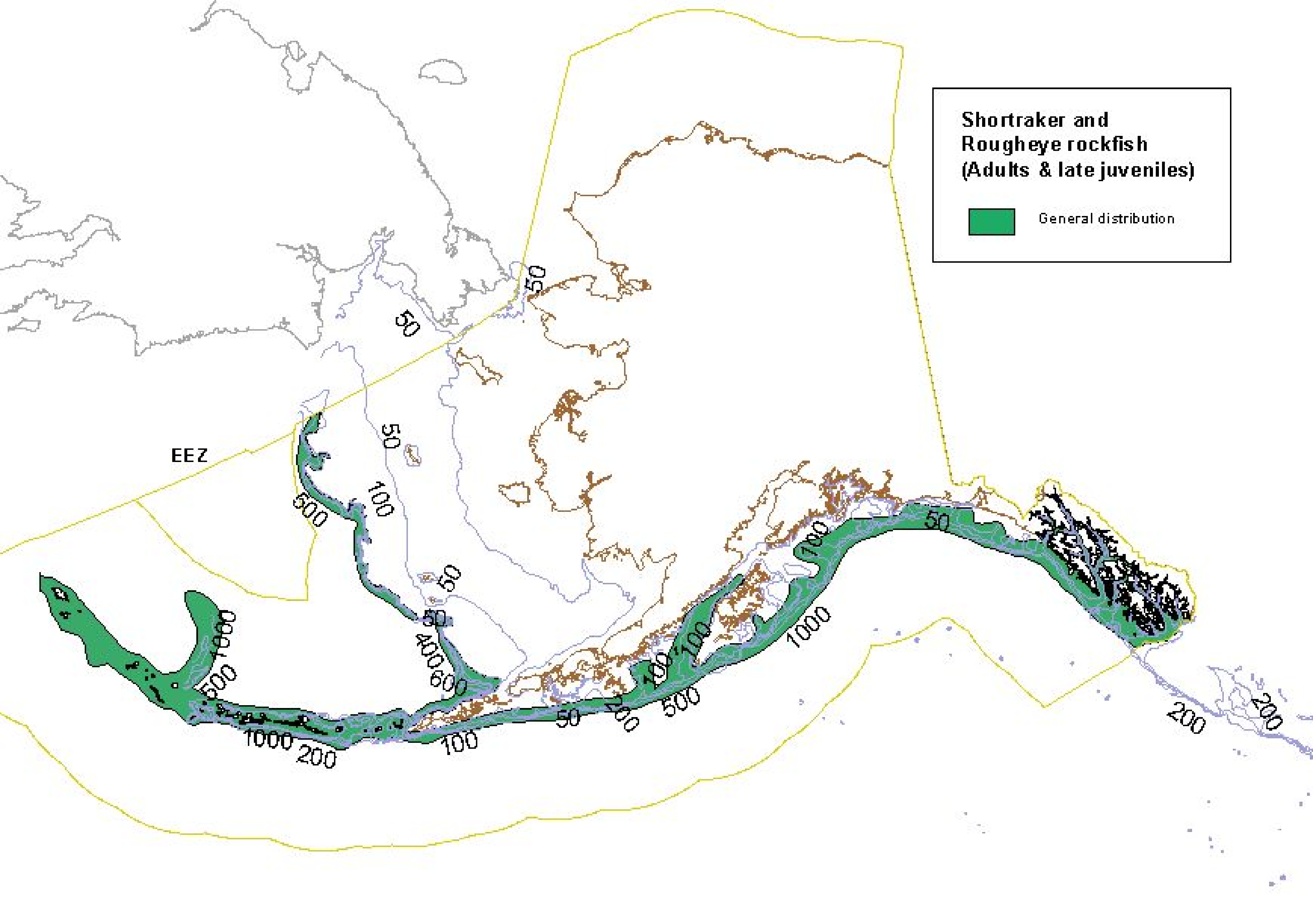

Walleye Pollock (adults)
General distribution
Known Concentration
EEZ
50
100
500
1000
200
400



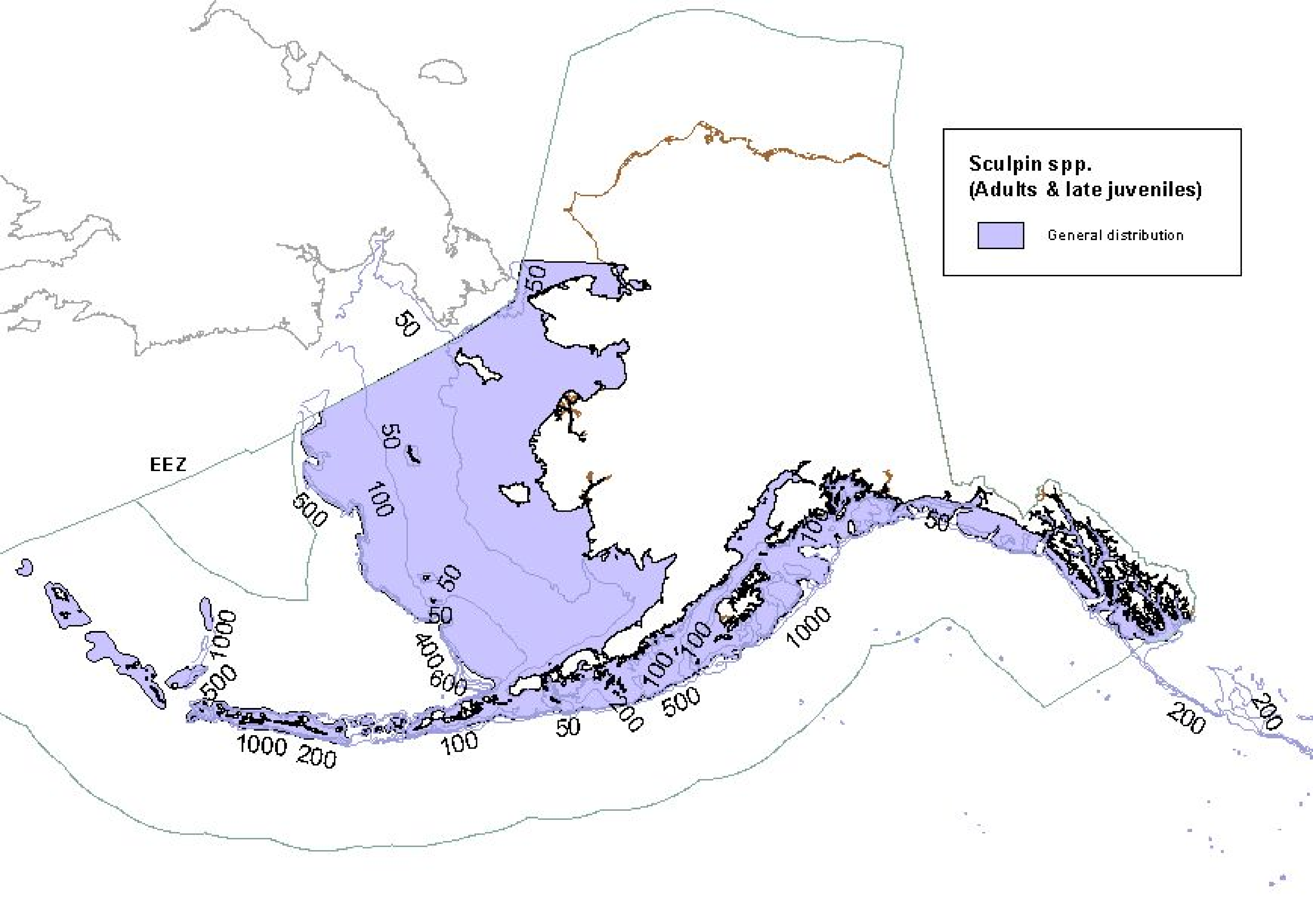
Yellowfin sole
(Adults & late juveniles)
General distribution
Known Concentration
EEZ
50
100
200
400
500
600
1000

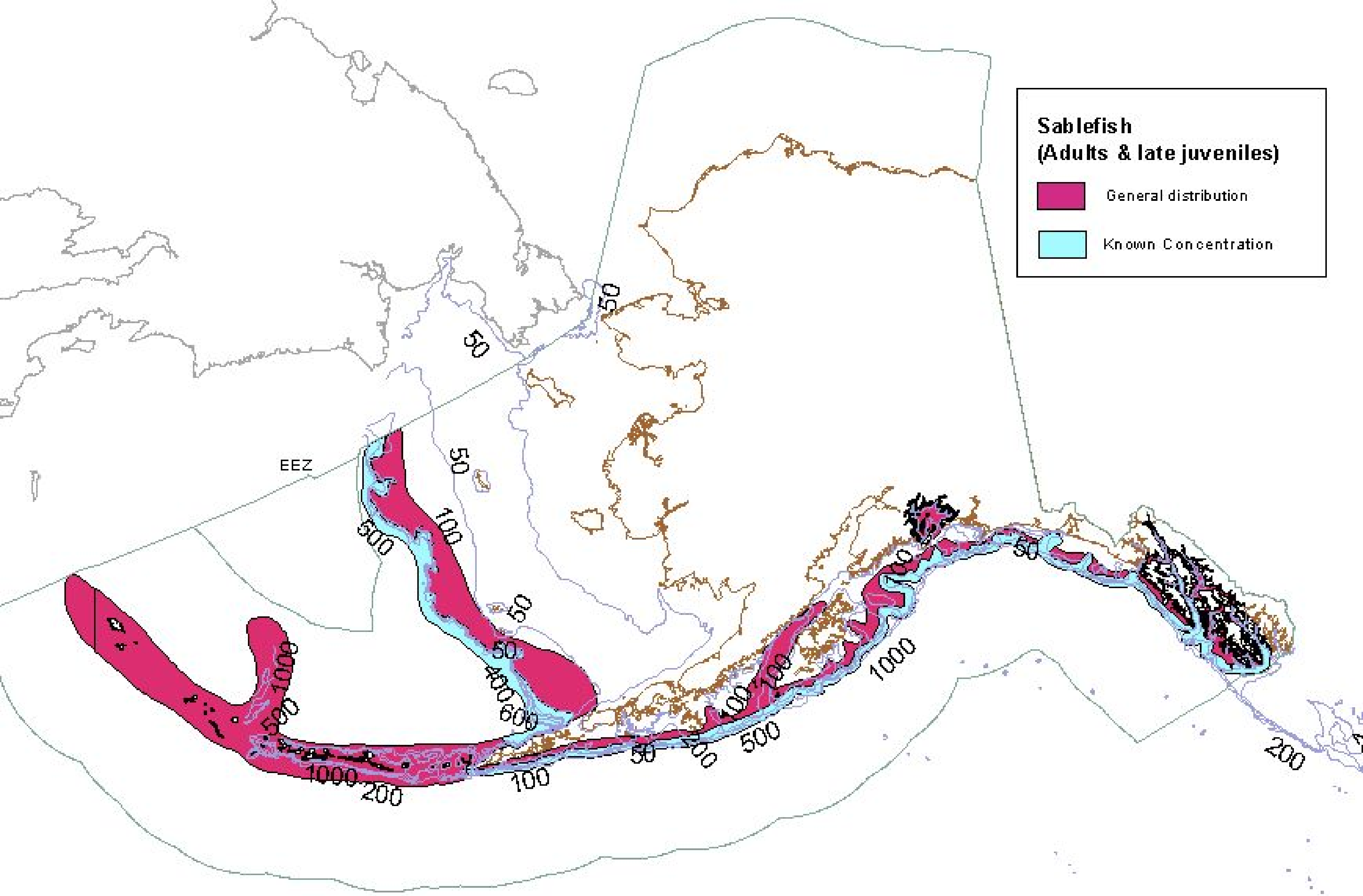

Thornyhead rockfish
(Adults & late juveniles)
General distribution
EEZ
50
50
50
100
500
50
50
400
600
1000
500
1000
200
100
50
200
500
100
100
1000
100
50
200
200

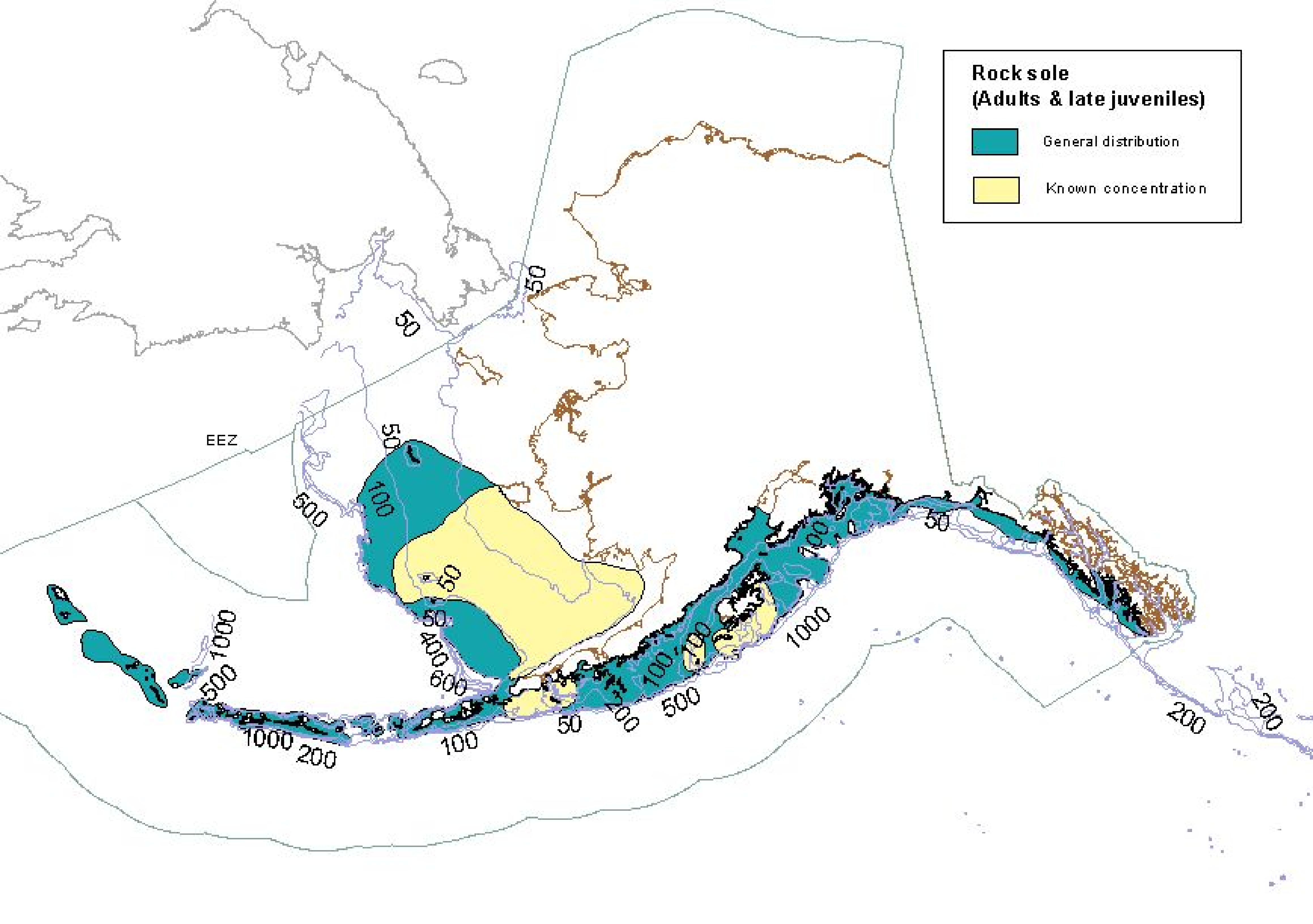

Alaska plaice
(Adults & late juveniles)
General distribution
Known Concentration
EEZ
50
100
200
400
500
600
1000

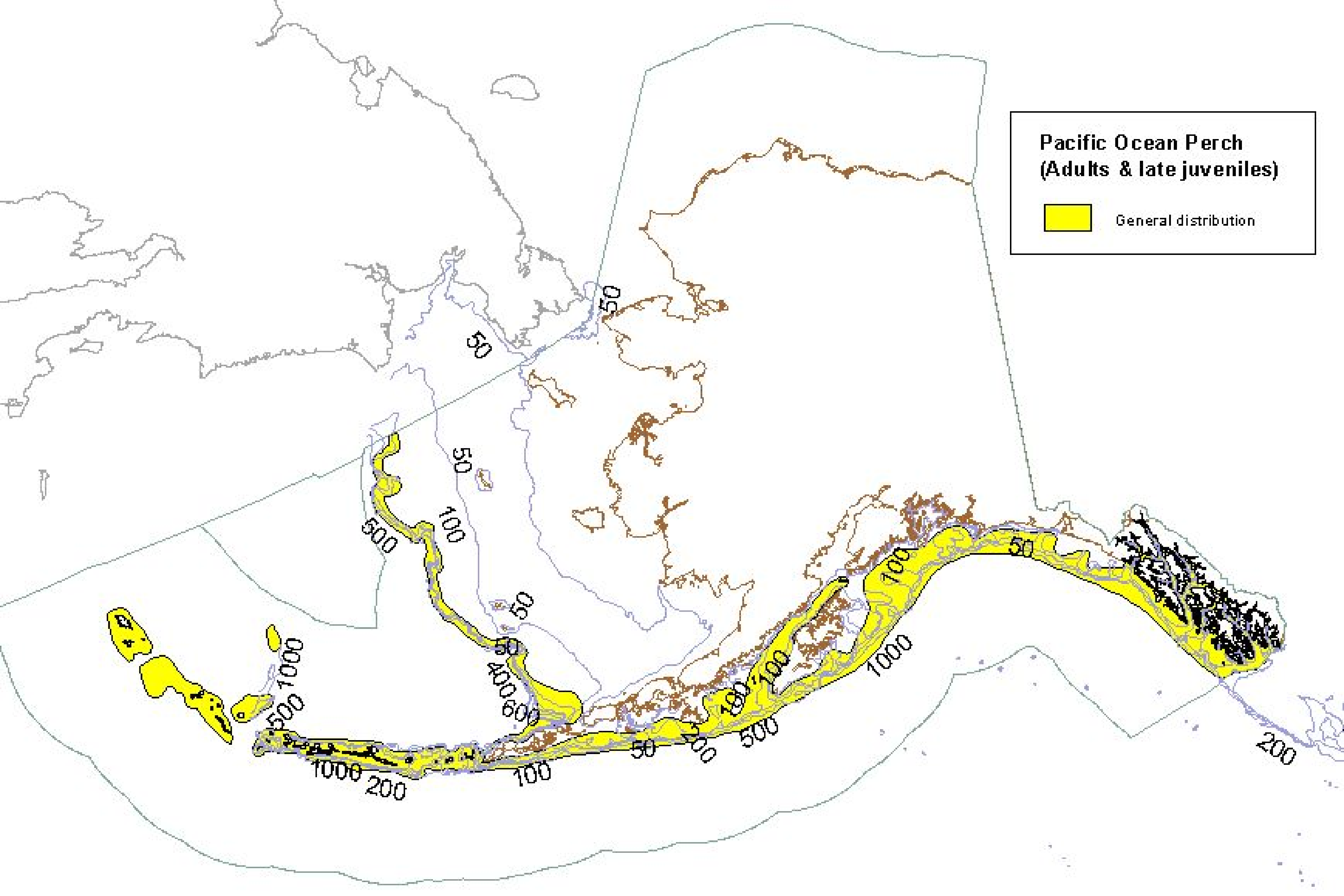


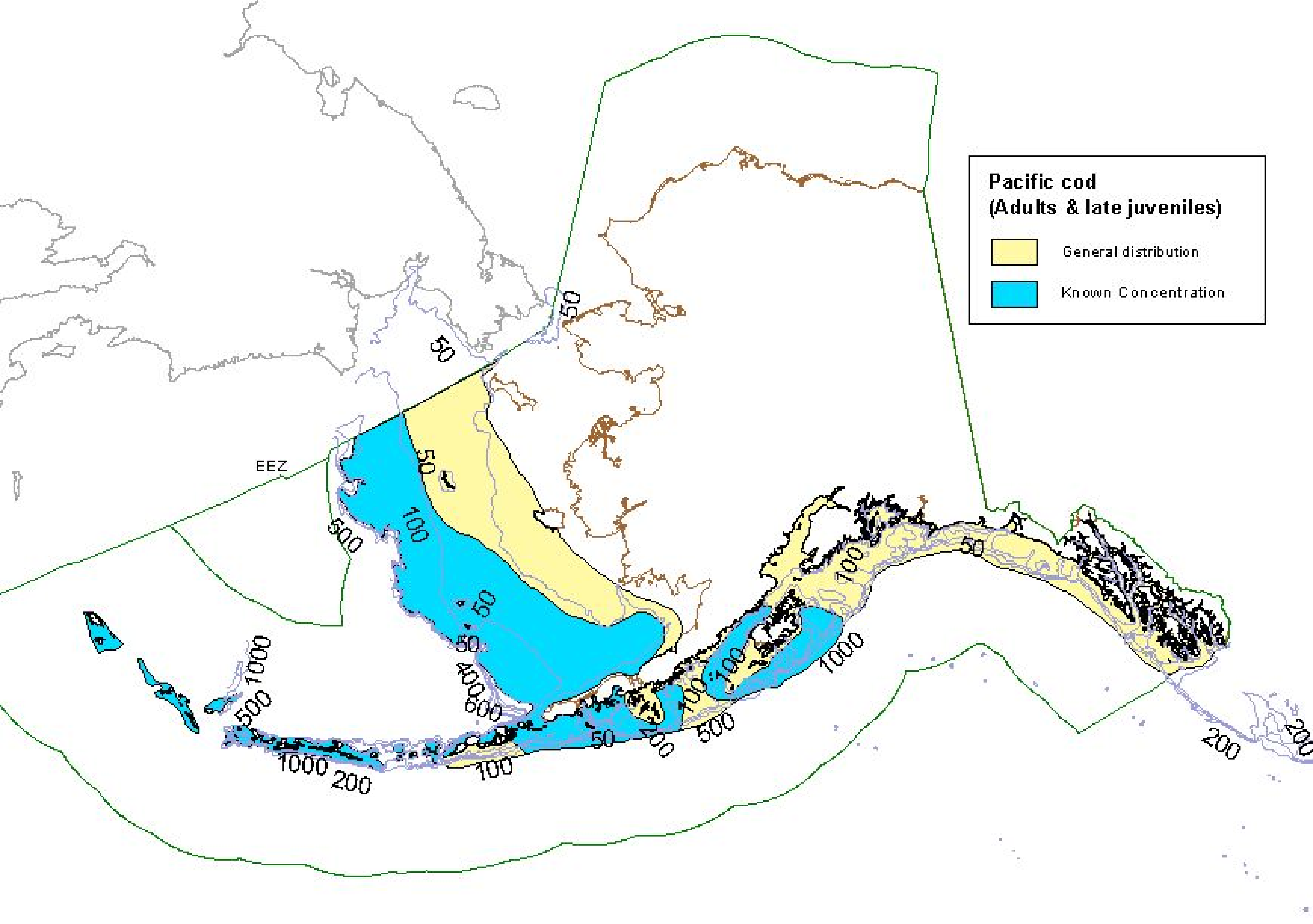
Shortraker and
Rougheye rockfish
(Adults & late juveniles)
General distribution
EEZ
50
50
50
100
500
50
50
400
600
1000
500
1000
200
100
50
200
500
100
100
1000
100
50
200
200

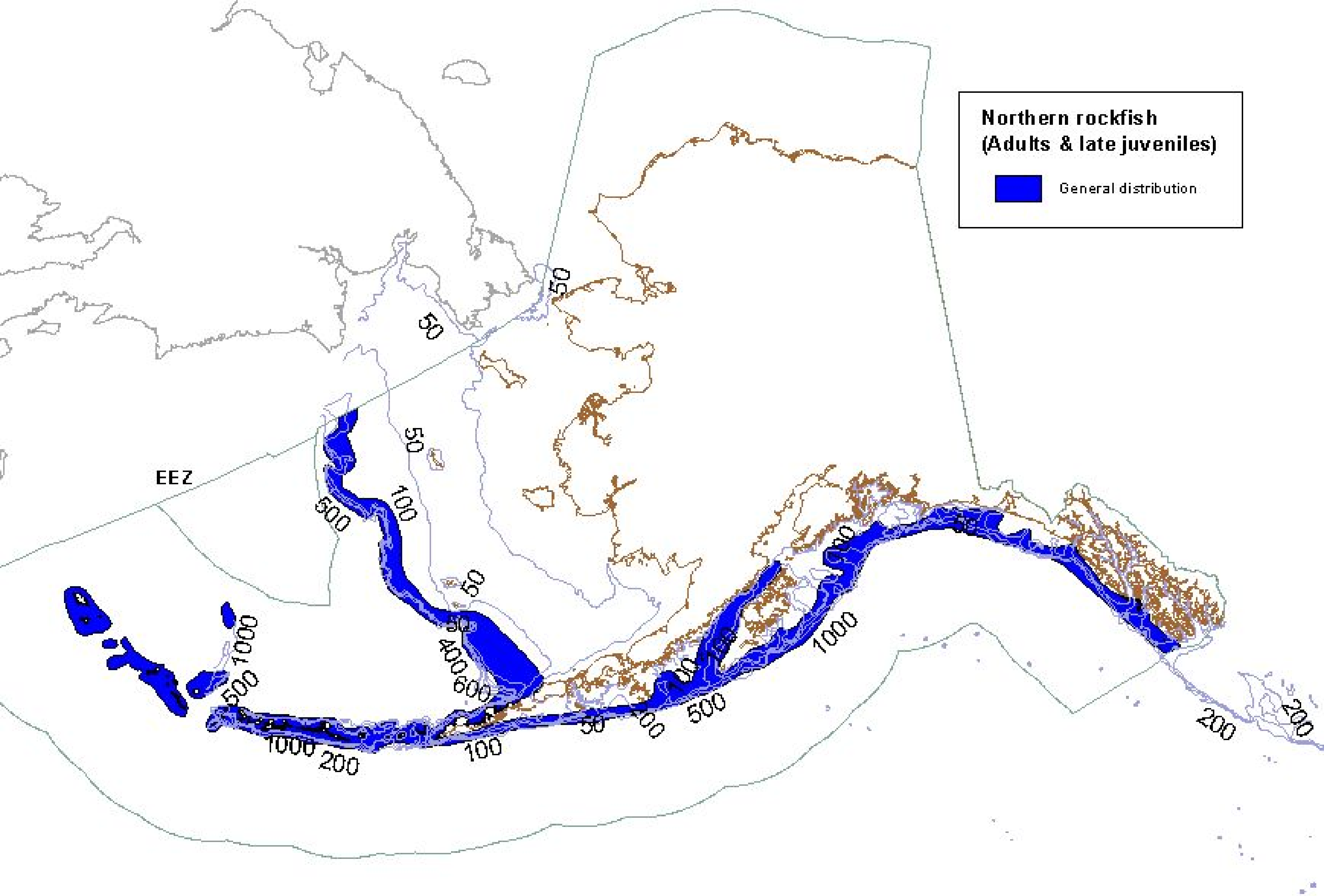

Sculpin spp.
(Adults & late juveniles)
General distribution
EEZ
50
50
50
100
500
50
50
400
600
1000
500
1000
200
100
50
200
500
100
100
1000
100
50
200
200


Sablefish
(Adults & late juveniles)
General distribution
Known Concentration
EEZ
50
100
200
400
500
600
1000

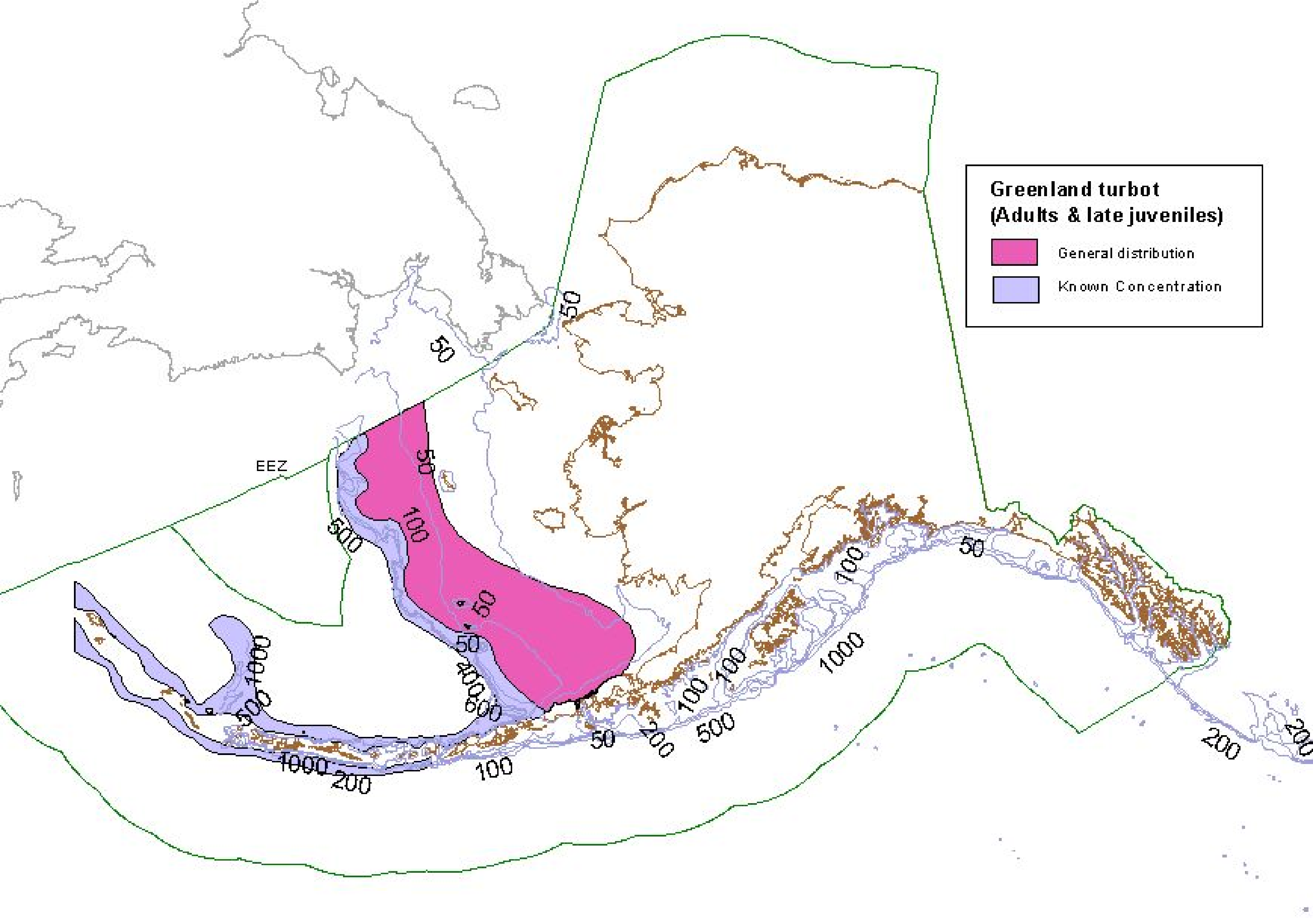

Rock sole
(Adults & late juveniles)
General distribution
Known concentration
EEZ
50
100
200
400
500
600
1000


Pacific Ocean Perch
(Adults & late juveniles)
General distribution
50
50
50
100
500
50
50
400
600
1000
500
1000
200
100
50
200
500
100
100
1000
100
50
200

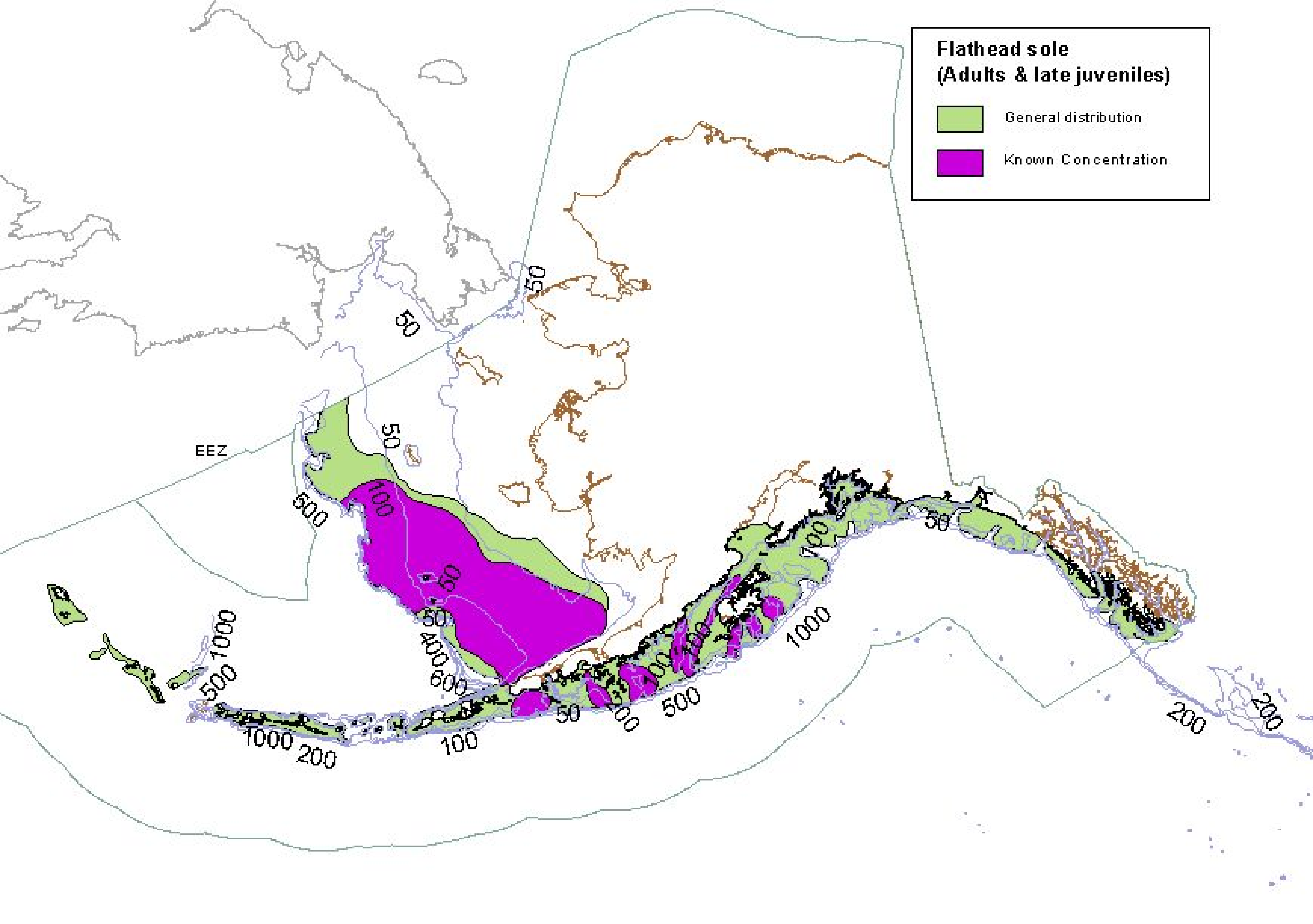

Pacific cod
(Adults & late juveniles)
General distribution
Known Concentration
EEZ
50
100
200
400
500
600
1000



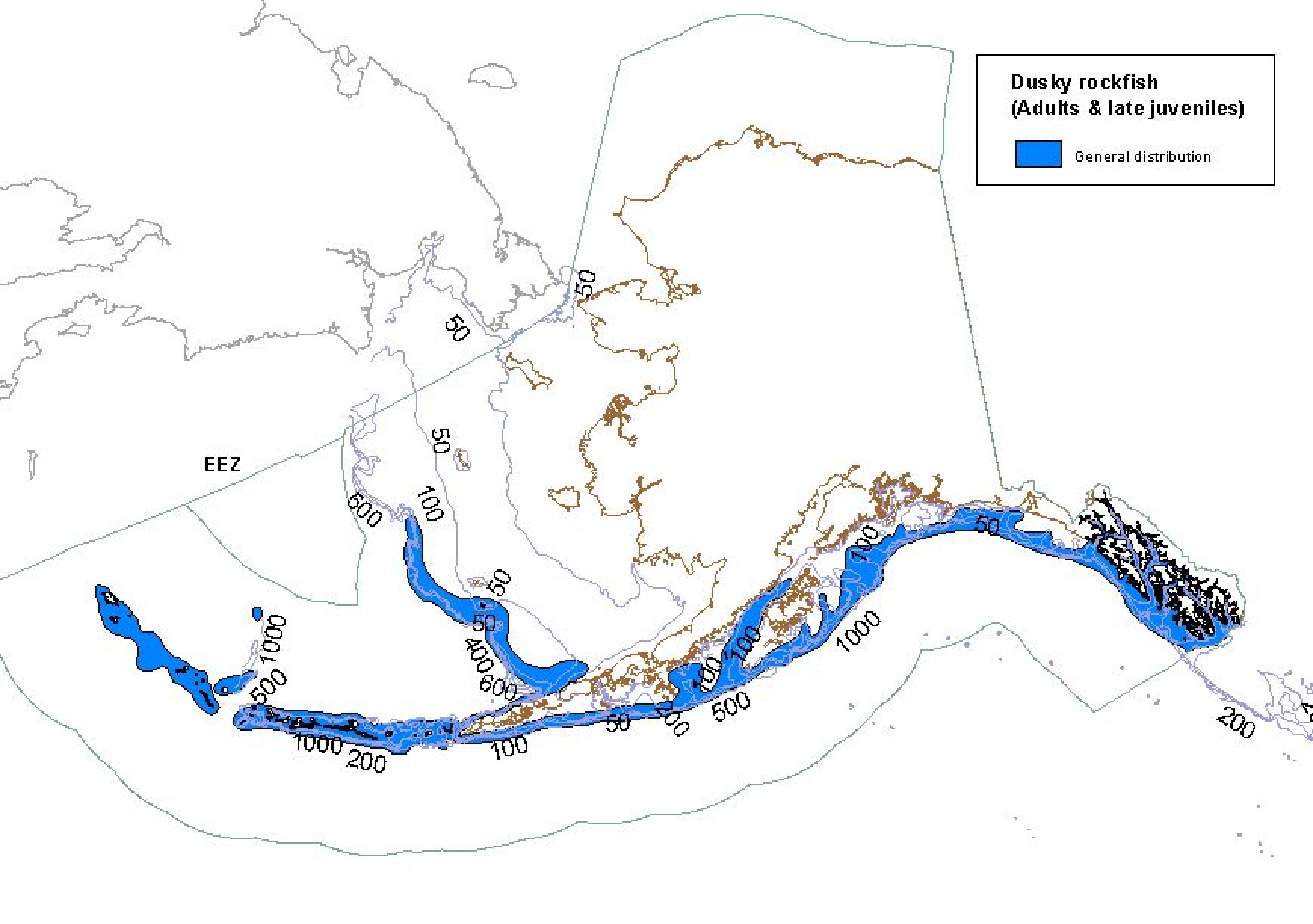
Northern rockfish
(Adults & late juveniles)
General distribution
EEZ
50
100
200
400
500
600
1000



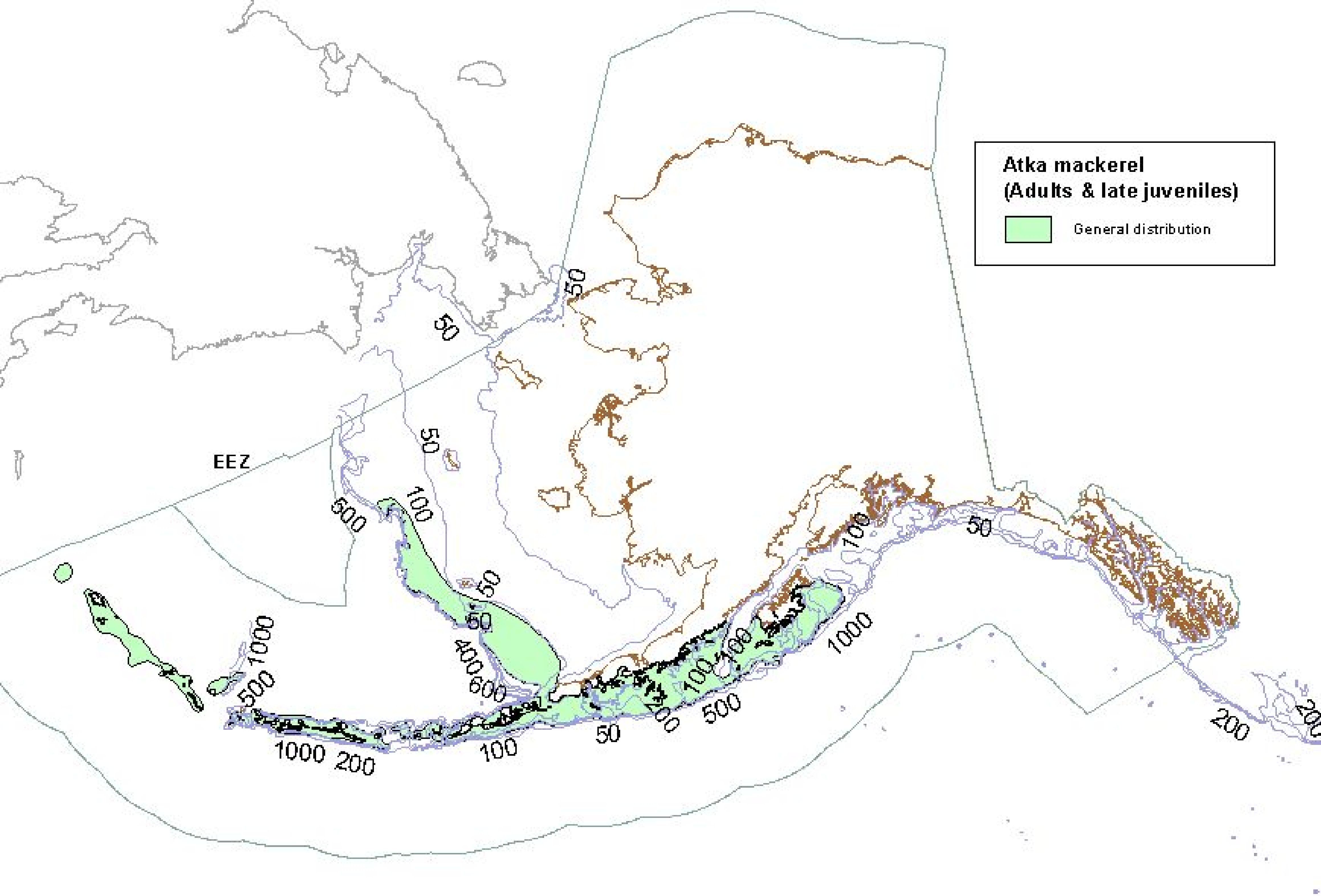
Greenland turbot
(Adults & late juveniles)
General distribution
Known Concentration
EEZ



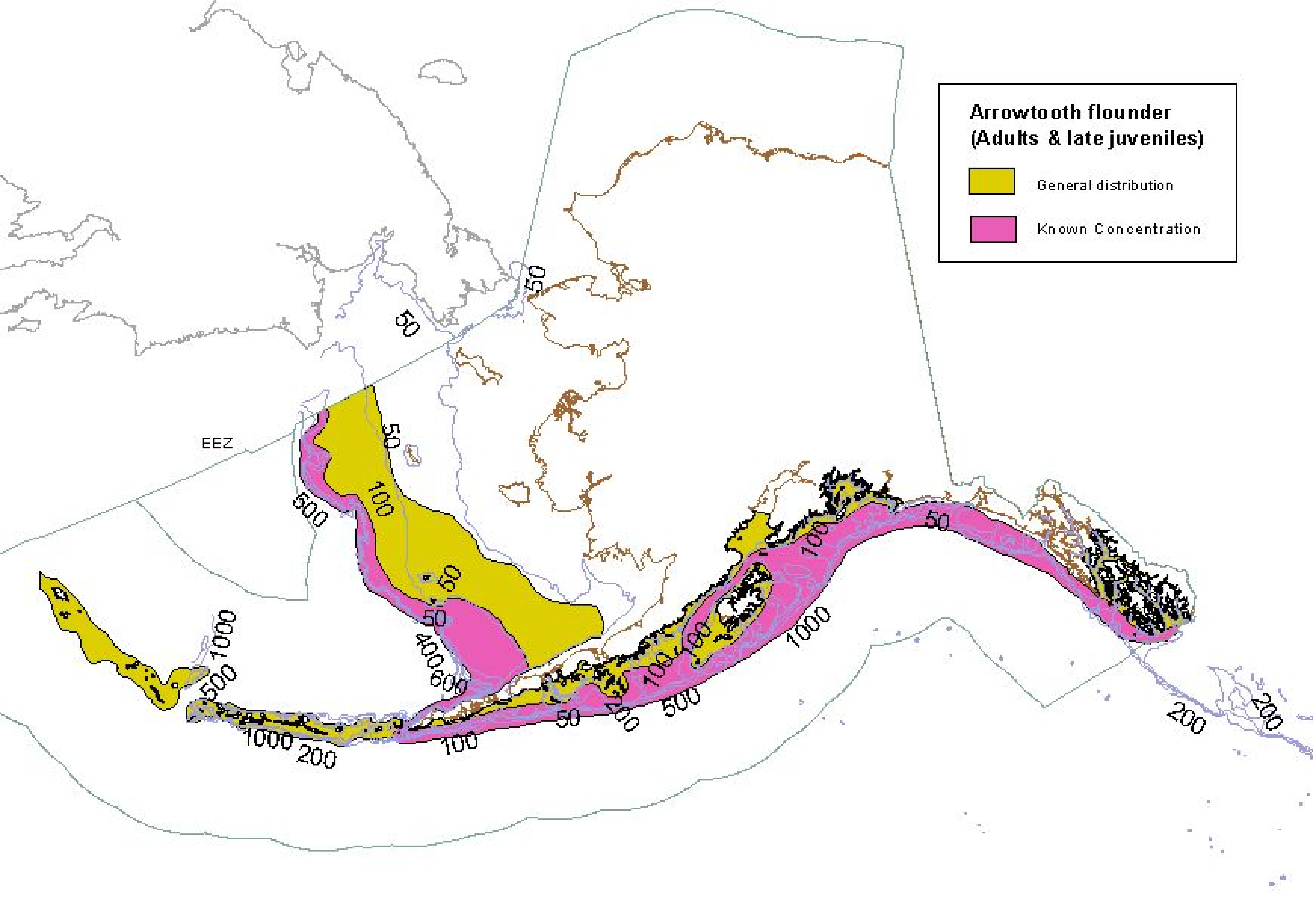
Flathead sole
(Adults & late juveniles)
General distribution
Known Concentration
EEZ
50
100
200
400
500
600
1000



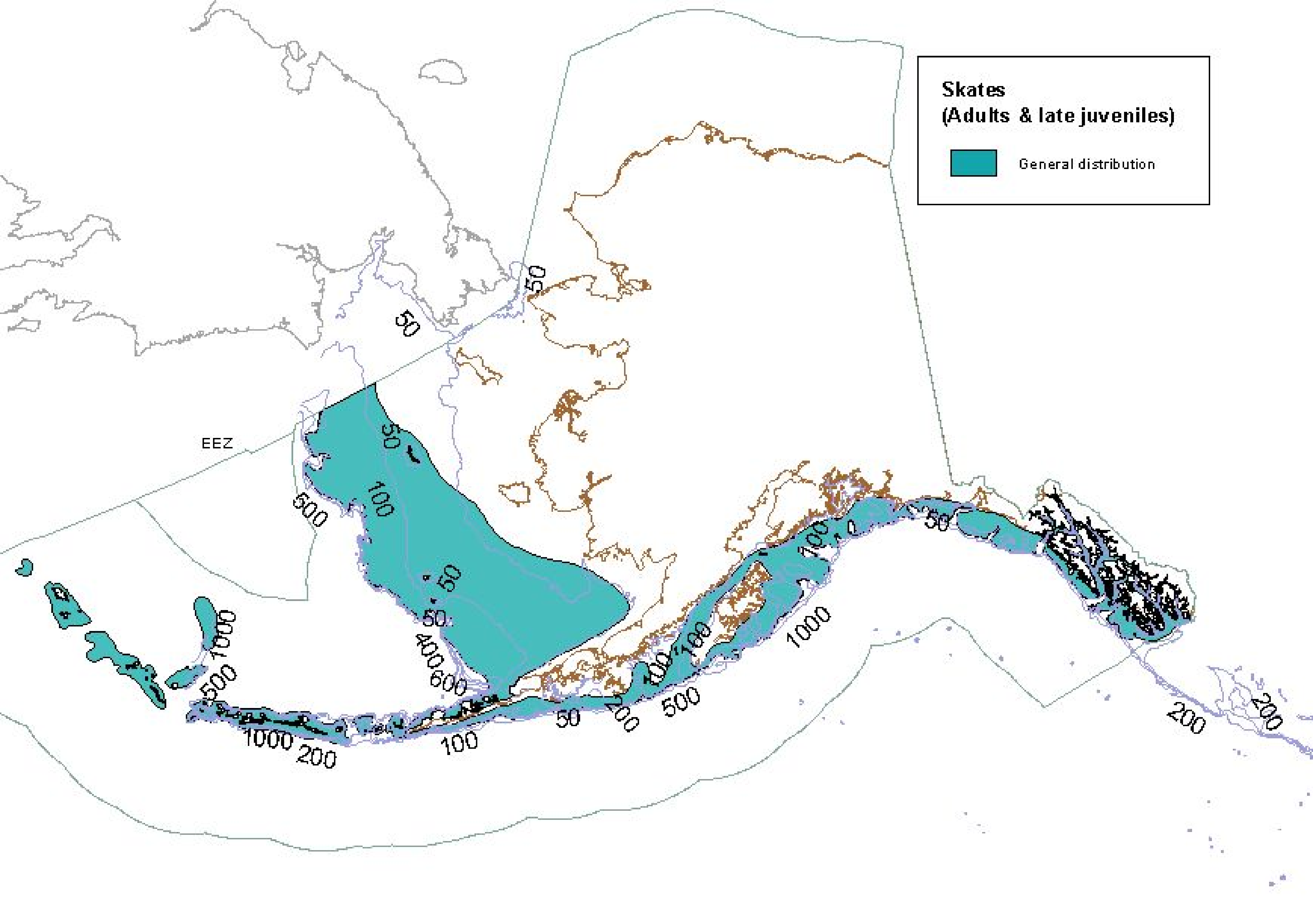
Dusky rockfish
(Adults & late juveniles)
General distribution
EEZ
50
100
200
400
500
600
1000



Atka mackerel
(Adults & late juveniles)
General distribution
EEZ
50
100
200
400
500
600
1000



Arrowtooth flounder
(Adults & late juveniles)
General distribution
Known Concentration
EEZ
50
100
200
400
500
600
1000



Skates
(Adults & late juveniles)
General distribution
EEZ
50
100
200
400
500
600
1000

6.2 GOA Groundfish

<u>EFH definition for GOA Walleye Pollock</u>

Eggs (duration to 14 days)- Level 1
Pelagic waters along the inner, middle, and outer continental shelf and the upper slope in the Gulf of Alaska from Dixon Entrance to 170EW. Spawning concentrations occur in Shelikof Strait (late March), in the Shumagin Islands (early March), the east side of Kodiak Island and near Prince William Sound. Oceanographic features that eggs may be associated with are gyres.

Larvae (duration 14-60 days)-Level 1
Epipelagic waters of the water column along the middle and outer continental shelf in the Gulf of Alaska from Dixon Entrance to 170EW. Feeding areas are those that contain copepod, naupli and small euphausiids. Oceanographic features that larvae may be associated with are gyres and fronts.

Juveniles (.4-4.5 years)- Level 1
Pelagic waters along the inner, mid and outer continental shelf in the Gulf of Alaska from Dixon Entrance to 170EW. Feeding areas are those that contain pelagic crustaceans, copepods and euphausiids. Oceanographic features that juveniles may be associated with are fronts and the thermocline.

Adults (4.5+ years)- Level 2
Pelagic waters from 70-200m along the outer continental shelf and basin in the Gulf of Alaska from Dixon Entrance to 170EW. Feeding areas are those that contain pelagic crustaceans and fish. Oceanographic features that adults are associated with are fronts and upwelling. Spawning concentrations occur in Shelikof Strait, in the Shumagin Islands, the east side of Kodiak Island and near Prince William Sound in late winter. Area in GOA where greatest abundance occurs are between 147EW to 170EW at depths less than 300m.

<u>EFH definition for GOA Pacific cod</u>

Eggs (duration 15-20 days)-Level 0_a
Areas of mud, sandy mud, muddy sand and sand along the inner, middle and outer continental of the Gulf of Alaska from Dixon Entrance to 170EW in winter and spring.

Larvae (duration unknown)-Level 0_a
Epipelagic waters of the Gulf of Alaska from Dixon Entrance to 170°W in winter and spring.

Early Juveniles(up to 2 years)-Level 0_a
Areas of mud, sandy mud, muddy sand and sand along the inner and middle continental shelf and the lower portion of the water column of the Gulf of Alaska from Dixon Entrance to 170°W. Feeding areas are those containing small invertebrates (e.g., mysids, euphausiids and shrimp).

Late Juveniles(2-5 years)-Level 1
Areas of mud, sandy mud, muddy sand and sand along the inner and middle continental shelf and the lower portion of the water column of the Gulf of Alaska from Dixon Entrance to 170EW. Feeding areas are those containing pollock, flatfish, and crab.

Adults(5+ years)- Level 2
Areas of mud, sandy mud, muddy sand and sand along the inner, middle and outer continental shelf up to 500m and the lower portion of the water column of the Gulf of Alaska from Dixon Entrance to 170EW. Feeding areas are those containing pollock, flatfish, and crab. Spawning occurs in January-May.

EFH definition for GOA Deep water flatfish, Dover sole

Eggs- Level 0_a
Pelagic waters along the inner, middle and outer continental shelf, during spring and summer, of the Gulf of Alaska from Dixon Entrance to 170EW.

Larvae(duration up to 2 years)-Level 0_a
Pelagic waters along the inner, middle and outer continental shelf and upper slope of the Gulf of Alaska from Dixon Entrance to 170EW.

Early Juveniles (up to 3years)-Level 0_a
Areas of sand and mud along the inner and middle continental slope and the lower portion of the water column of the Gulf of Alaska from Dixon Entrance to 170EW. Feeding areas are those containing polychaetes, amphipods and annelids.

Late Juveniles (3-5 years)-Level 0_a
Areas of sand and mud along the inner and middle continental slope and the lower portion of the water column of the Gulf of Alaska from Dixon Entrance to 170E W. Feeding areas are those containing polychaetes, amphipods and annelids.

Adults (5+ years)-Level 1
Areas of sand and mud along the middle to outer continental shelf and upper slope deeper than 300m and the lower portion of the water column of the Gulf of Alaska from Dixon Entrance to 170E W. Winter and spring spawning and summer feeding on soft substrates (sand and mud) of the continental shelf and upper slope and a shallower summer distribution mainly on the middle to outer portion of the shelf and upper slope. Feeding areas are those containing polychaetes, amphipods, annelids and mollusks.

EFH Definition for GOA Shallow water complex, Yellowfin Sole

Eggs (duration unknown) - Level 0_a
Pelagic inshore waters of the central and western GOA during summer months.

Larvae (duration 2-3 months) - Level 0_a
Pelagic inshore waters and inner continental shelf regions of the central and western GOA during summer and autumn months.

Early Juveniles (to 5.5 years old) - Level 0_a
Demersal areas (bottom and lower portion of the water column) on the inner, middle and outer portions of the continental shelf (down to 250 m) and within nearshore bays of the central and western GOA.

Late Juveniles (5.5 - 9 years old) - Level 1
Areas of sandy bottom along with the lower portion of the water column within nearshore bays and on the inner, middle and outer portions of the continental shelf (down to 250 m) of the central and western GOA. Feeding areas would be those containing polychaetes, bivalves, amphipods and echiurids.

Adults (9+ years old) - Level 2
Areas of sandy bottom along with the lower portion of the water column on the inner, middle and outer portions of the continental shelf (down to 250 m) of the central and western GOA. Areas of known concentrations vary seasonally (known for the Bering Sea). Adult spawning areas known for the eastern Bering Sea (see Bering Sea EFH definition). Summer (June-October) feeding concentrations of adults known in the Bering Sea. Feeding areas would be those containing polychaetes, bivalves, amphipods and echiurids. In winter, yellowfin sole adults migrate to deeper waters of the shelf (100-200 m) south of 60E N to the Alaskan Peninsula.

<u>EFH Definition for GOA Shallow water complex, Rock Sole</u>

Eggs (duration unknown) - Level 0_a
Areas of pebbles and sand at depths of 125-250 m in winter (December-March) along the shelf-slope break in the GOA from Dixon Entrance to 170°W.

Larvae (duration 2-3 months) - Level 0_a
Pelagic waters of the GOA from Dixon Entrance to 170°W over the inner, middle and outer portions of the continental shelf and the slope.

Early Juveniles (to 3.5 years old) - Level 0_a
Inner, middle and outer portions of the continental shelf (down to 250 m) of the Gulf of Alaska and the lower portion of the water column from Dixon Entrance to 170°W. Feeding areas would be those containing polychaetes, bivalves, amphipods and crustaceans.

Late Juveniles (3.5 - 8 years old) - Level 1
Areas of pebbles and sand and the lower portion of the water column within nearshore bays and on the inner, middle and outer portions of the continental shelf (down to 250 m) of the Gulf of Alaska from Dixon Entrance to 170°W. Feeding areas would be those containing polychaetes, bivalves, amphipods and crustaceans.

Adults (8+ years old) - Level 2
Areas of pebbles and sand and the lower portion of the water column on the inner, middle and outer portions of the continental shelf (down to 250 m) of the GOA from Dixon Entrance to 170EW. Areas of known concentrations vary seasonally and include adult spawning areas in winter (see Eggs/Spawning Adults) and feeding areas in summer (May-October) in the Bering Sea (see BSAI EFH definition). Feeding areas would be those containing polychaetes, bivalves, amphipods and crustaceans.

<u>EFH definition for GOA Rex sole</u>

Eggs-Level 0_a
Pelagic waters of the inner, middle, and outer continental shelf of the Gulf of Alaska from Dixon Entrance to 170EW during the months between February and July.

Larvae-Level 0_a
Pelagic waters of the inner, middle, and outer continental shelf of the Gulf of Alaska from Dixon Entrance to 170E W during the spring and summer months.

Juveniles (up to 2 years)-Level 0_a
Areas of gravel, sand and mud along the inner, middle to outer continental shelf deeper than 300m, and the lower portion of the water column, of the Gulf of Alaska from Dixon Entrance to 170EW. Feeding areas are those containing polychaetes, amphipods, euphausiids and Tanner crab.

Adults(2+ years)-Level 1
Areas of gravel, sand and mud along the inner, middle to outer continental shelf deeper than 300m, and the lower portion of the water column, of the Gulf of Alaska from Dixon Entrance to 170EW. Feeding areas are those containing polychaetes, amphipods, euphausiids and Tanner crab. Spawning occurs from February through July along areas of sand, mud and gravel substrates of the continental shelf.

<u>EFH definition for GOA Flathead sole</u>

Eggs (duration unknown)-Level 0_a
Pelagic waters (January-April) along the inner, middle and outer continental shelf in the Gulf of Alaska from Dixon Entrance to 170°W.

Larvae (duration unknown)-Level 0_a
Pelagic waters along the inner, middle and outer continental shelf in the Gulf of Alaska from Dixon Entrance to 170°W. Feeding areas are those containing phytoplankton and zooplankton.

Juveniles (2-3 years)-Level 1
Areas of sand and mud along the inner, middle and outer continental shelf and upper slope and the lower portion of the water column in the Gulf of Alaska from Dixon Entrance to 170°W. Feeding areas are those containing polychaetes, bivalves, ophiuroids, pollock and small tanner crab.

Adults (3+ years)-Level 2
Areas of sand and mud along the inner, middle and outer continental shelf and upper slope and the lower portion of the water column, in the Gulf of Alaska from Dixon Entrance to 170°W. Feeding areas, primarily on the inner, middle and outer shelf in spring, summer and fall, are those containing polychaetes, bivalves, ophiuroids, pollock, small tanner crab and other crustaceans. Spawning areas in winter and early spring are located primarily on the outer shelf.

<u>EFH definition for GOA Arrowtooth flounder</u>

Eggs (duration unknown)-Level 0_a
Pelagic waters (November - March) along the inner, middle, and outer continental shelf in the Gulf of

Alaska from Dixon Entrance to 170° W.

Larvae(duration 2-3 months)-Level 0_a
Pelagic waters along the inner and outer continental shelf and nearshore bays during spring and summer in the Gulf of Alaska from Dixon Entrance to 170° W. Feeding areas are those that contain phytoplankton and zooplankton.

Early Juveniles (to 2 years old)-Level 0_a
Areas of gravel, mud, and sand and the water column of the inner continental shelf and adjacent nearshore bays in the Gulf of Alaska from Dixon Entrance to 170°W.

Late Juveniles (1-4 yrs.)-Level 1
Areas of gravel, mud, and sand along the inner, middle, and outer continental shelf and upper slope and the lower portion of the water column in the Gulf of Alaska from Dixon Entrance to 170°W. Feeding areas are those that contain euphausiids, crustaceans, amphipods and pollock.

Adults (4+ years)-Level 2
Areas of gravel, mud, and sand along the inner, middle, and outer continental shelf, upper slope and nearshore bays and the lower portion of the water column in the Gulf of Alaska from Dixon Entrance to 170°W. Summer feeding areas on the middle and outer shelf would be those containing gadids, euphausiids, and other fish. Spawning areas in winter are on the outer shelf and upper slope regions.

<u>EFH definition for GOA Sablefish</u>

Eggs (duration 14-20 days)- Level 0_a
Pelagic waters of the continental shelf and in basin areas from 200-3000m extending to the seaward boundaries of the EEZ of the Gulf of Alaska from Dixon Entrance to 170° W from late winter to early spring (December-April) .

Larvae (duration up to 3 months)-Level 0_a
Epipelagic waters of the middle to outer continental shelf, the slope and basin areas of the Gulf of Alaska from Dixon Entrance to 170° W during late spring-early summer months (April - July).

Early Juveniles (up to 2 years)- Level 0_a
Pelagic waters, during first summer, along the outer, middle, and inner continental shelf of the Gulf of Alaska from Dixon Entrance to 170°W. Areas of soft-bottom in nearshore bays and island passes in the demersal, semi-demersal regions, after the first summer till end of second summer.

Late Juveniles (2-5 years)- Level 1
Areas of soft bottom generally deeper than 100m and associated with the continental slope and deep shelf gulleys and fjords (presumably demersal within the lower portion of the water column) of the Gulf of Alaska from Dixon Entrance to 170° W. Feeding areas are those containing mesopelagic and benthic fishes, benthic invertebrates and jellyfish.

Adults (5+years)- Level 2
Areas of soft bottom deeper than 200m (presumably within the lower portion of the water column) associated with the continental slope and deep shelf gulleys and fjords (such as Prince William Sound and

those in southeastern Alaska) of the Gulf of Alaska from Dixon Entrance to 170°W. Feeding areas would be those containing mesopelagic and benthic fishes, benthic invertebrates and jellyfish. A large portion of the adult diet is comprised of gadid fishes mainly pollock.

EFH definition for GOA Slope rockfish, Pacific Ocean Perch

Eggs (internal incubation, ~90days) No EFH definition determined.
Infernal fertilization and incubation. Incubation is assumed to occur during the winter months.

Larvae (duration 60-180 days)- Level 0_a
Pelagic waters of the inner, middle to outer continental shelf, the upper and lower slope and the basin areas extending to the seaward boundary of the EEZ of the Gulf of Alaska from Dixon Entrance to 170°W, during the spring and summer months.

Early Juveniles (larval stage to 3 years) - Level 0_a
Initially pelagic, then demersal in very rocky areas of the inner continental shelf of the Gulf of Alaska from Dixon Entrance to 170 degrees W.

Late Juveniles (3 to 10 years) - Level 1
Areas of cobble, gravel, mud, sandy mud and muddy sand along the inner, middle to outer continental shelf and upper slope areas, shallower than adults, middle to lower portion of the water column, of the Gulf of Alaska from Dixon Entrance to 170EW. Feeding areas are those containing euphausiids.

Adults (10+ years)- Level 1
Areas of cobble, gravel, mud, sandy mud or muddy sand along the outer continental shelf and upper slope areas from 180-420m (actual depths sampled) of the Gulf of Alaska from Dixon Entrance to 170EW. Feeding areas are those containing euphausiids. Areas of high concentrations tend to vary seasonally and may be related to spawning behavior, in summer adults inhabit shallower depths (180-250m) and in the fall they migrate farther offshore (300-420m).

EFH definition for GOA slope rockfish, Shortraker and Rougheye rockfish

Eggs- No EFH definition determined.
Internal fertilization and incubation.

Larvae- Level 0_b
Pelagic waters of the inner, middle, and outer continental shelf, the upper and lower slope and the basin areas extending to the seaward boundary of the EEZ of the Gulf of Alaska from Dixon Entrance to 170°W, during the spring and summer months.

Early Juveniles (up to 20 cm) - Level 0_{a-b}
Between nearshore waters and outer continental shelf of the Gulf of Alaska from Dixon Entrance to 170°W.

Late Juveniles (greater than 20 cm) - Level 0_b and level 1
Areas shallower than adult along the continental shelf of the Gulf of Alaska (includes substrate and water column) from Dixon Entrance to 170°W. Juvenile shortraker rockfish have been observed on only a few

rare occasions. Presence presumed somewhere between nearshore and outer continental shelf between Dixon Entrance and 170°W.

Adults (15+ years)-Level 1
Areas of mud, sand, rock, sandy mud, cobble, muddy sand and gravel at depths ranging from 200-500 m and the lower third of the water column, of the outer continental shelf and the upper slope of the Gulf of Alaska from Dixon Entrance to 170°W. Fishery concentrations at 300-500m. Feeding areas would be those areas where shrimps, squid and myctophids occur.

<u>EFH definition for GOA slope rockfish, Northern rockfish</u>

Eggs- No EFH definition determined.
Internal fertilization and incubation.

Larvae- Level 0_b
Pelagic waters of the inner, middle to outer continental shelf, the upper and lower slope and the basin areas extending to the seaward boundary of the EEZ of the Gulf of Alaska from Dixon Entrance to 170°W, during the spring and summer months.

Early juveniles (up to 25cm)-Level 0_b
Pelagic waters of the inner, middle to outer continental slope, of the Gulf of Alaska from Dixon Entrance to 170°W.

Late Juveniles (greater than 25cm)-Level 1
Areas of cobble and rock along the shallower regions (relative to adults) of the outer continental shelf and the middle and lower portions of the water column of the Gulf of Alaska from Dixon Entrance to 170°W.

Adults (13+ years)-Level 1
Areas of cobble and rock along the outer continental slope and upper slope regions and the middle and lower portion of the water column of the Gulf of Alaska from Dixon Entrance to 170°W. Areas of relatively shallow banks of the outer continental shelf have been found to have concentrated populations.

<u>EFH definition for GOA Pelagic shelf rockfish, Dusky rockfish</u>

Eggs- No EFH definition determined.
Internal fertilization and incubation.

Larvae- Level 0_b
Pelagic waters of the inner, middle to outer continental shelf, the upper and lower slope and the basin areas extending to the seaward boundary of the EEZ of the Gulf of Alaska from Dixon Entrance to 170°W, during the spring and summer months.

Early juveniles (less than 25cm)-Level 0_b
Pelagic waters of the inner, middle, and outer continental shelf of the Gulf of Alaska from Dixon Entrance

to 170°W.

Late Juveniles (greater than 25cm)- Level 0_a
Areas of cobble, rock and gravel along the inner, middle, and outer continental shelf of the Gulf of Alaska from Dixon Entrance to 170°W. Location in water column is currently unknown.

Adults (up to 50 years)-Level 1
Areas of cobble, rock and gravel along the outer continental shelf and upper slope region and the middle to lower portion of the water column of the Gulf of Alaska from Dixon Entrance to 170°W. Feeding areas are those containing euphausiids. Also found in nearshore waters of Southeast Alaska along rocky shores at depths less than 50m.

EFH definition for GOA Demersal shelf rockfish, Yelloweye rockfish

Eggs- No EFH definition determined.
Internal fertilization and incubation

Larvae (< 6months)-Level 0_b
Epipelagic areas of the water column of the Gulf of Alaska from Dixon Entrance to 170°W during the spring and summer months.

Early Juveniles (to 10yrs.)-Level 0_a
Areas of rock and coral along the inner, middle and outer continental shelf, bays and island passages and the entire water column of the Gulf of Alaska from Dixon Entrance to 170°W. Concentrations of young juveniles (2.5-10cm) have been observed in areas of high relief (such as vertical walls, cloud sponges, fjord-like areas).

Late Juveniles (10-18yrs)- Level 1
Areas of rock and coral along the inner, middle and outer continental shelf, nearshore bays and island passages of the Gulf of Alaska from Dixon Entrance to 170°W and the lower portion of the water column. High concentrations are found associated with high relief with refuge spaces such as overhangs, crevices and caves.

Adults (18+ years)- Level 1
Areas of rock, coral and cobble along the inner, middle and outer continental shelf, upper slope, nearshore bays and island passages of the Gulf of Alaska from Dixon Entrance to 170°W from and the lower portion of the water column. High concentrations are found associated with high relief containing refuge spaces such as overhangs, crevices and caves. Feeding areas are those containing fish, shrimp and crab.

EFH definition for GOA Thornyhead rockfish

Eggs- Level 0_a
Pelagic waters of the Gulf of Alaska from Dixon Entrance to 170°W during the late winter and early spring.

Larvae (<15months)- Level 0_a
Pelagic waters extending to the seaward boundary of the EEZ of the Gulf of Alaska from Dixon Entrance to 170°W during the early spring through summer.

Juveniles(> 15 months)- Level 0_a
Areas of mud, sand, rock, sandy mud, cobble, muddy sand and gravel and the lower portion of the water column along the middle and outer continental shelf and upper slope of the Gulf of Alaska from Dixon Entrance to 170°W.

Adults- Level 1
Areas of mud, sand, rock, sandy mud, cobble, muddy sand and gravel and the lower portion of the water column along the middle and outer continental shelf and upper and lower slope of the Gulf of Alaska from Dixon Entrance to 170°W. Feeding areas are those containing shrimp, fish (cottids), and small crabs.

EFH definition for GOA Atka mackerel

Eggs (40-45 days)-Level 0_a
Areas of gravel, rock and kelp in shallow waters, island passes and the inner continental shelf of the Gulf of Alaska from Kodiak Island to 170°W.

Larvae (up to 6 months)-Level 0_a
Epipelagic waters of the middle and outer continental shelf, slope and extending seaward to the edge of the EEZ in the Gulf of Alaska from Kodiak Island to 170°W.

Juveniles (up to 2 years)-Level 0_a
Unknown habitat association; assumed to settle near areas inhabited by adults, but have not been observed in fishery or surveys.

Adults- Level 1
Areas of gravel, rock and kelp on the inner, middle and outer continental shelf and the entire water column (to the surface) in the Gulf of Alaska from Kodiak Island to 170°W. Feeding areas are those containing copepods, euphausiids and meso-pelagic fish (myctophids). Spawning occurs in nearshore (inner shelf and in island passes) rocky areas and in kelp in shallow waters in summer and early. Move to offshore deeper areas nearby in winter. Perform diurnal/tidal movements between demersal and pelagic areas.

EFH Definition for GOA Other species-Sculpins

Eggs - Level 0_a
All substrate types on the inner, middle and outer continental shelf of the Gulf of Alaska from Dixon Entrance to 170°W. Some species deposit eggs in rocky shallow waters near shore.

Larvae- Level 0_a
Pelagic waters of the inner, middle and outer continental shelf and slope of the Gulf of Alaska from Dixon Entrance to 170°W, predominately over the inner and middle shelf.

Juveniles - Level 0_a

Broad range of demersal habitats from intertidal pools, all shelf substrates (mud, sand, gravel, etc.) and rocky areas of the upper slope of the Gulf of Alaska from Dixon Entrance to 170°W.

Adults - Level 1
Broad range of demersal habitats from intertidal pools, all shelf substrates (mud, sand, gravel, etc.) and rocky areas of the upper slope of the Gulf of Alaska from Dixon Entrance to 170°W.

EFH definition for GOA other species-Skates

Eggs-Level 0_a
All bottom substrates of the upper slope and across the shelf throughout the Gulf of Alaska from Dixon Entrance to 170°W.

Larvae- No EFH definition determined.
Not applicable (no larval stage)

Juveniles-Level 0_a
Broad range of substrate types (mud, sand, gravel, and rock) and the water column on the shelf and the upper slope of the Gulf of Alaska from Dixon Entrance to 170°W.

Adults- Level 1
Broad range of substrate types (mud, sand, gravel, and rock) and the lower portion of the water column on the shelf and the upper slope of the Gulf of Alaska from Dixon Entrance to 170°W.

EFH Definition for GOA Other Species -Sharks

Eggs - No EFH definition determined.
Not applicable (most are oviparous)

Larvae - No EFH definition determined.
Not applicable (most species are oviparous/ no larval stage)

Juveniles and Adults-Level 0_a
All waters and substrate types in the inner, middle and outer continental shelf and slope of the Gulf of Alaska from Dixon Entrance to 170°W to the seaward edge of the EEZ.

EFH Definition for GOA Other Species -Octopus

Eggs-Level 0_a
All bottom substrates of the shelf throughout the Gulf of Alaska from Dixon Entrance to 170°W.

Larvae- No EFH definition determined.
Not applicable (no larval stage)

Juveniles and Adults-Level 0_a
Broad range of substrate types (mostly rock, gravel, and sand) and the lower portion of the water column on the shelf and the upper slope of the Gulf of Alaska from Dixon Entrance to 170°W. Feeding areas are

those containing crustaceans and molluscs.

EFH Definition for GOA Squid - Red Squid

Eggs-Level 0_a
Areas of mud and sand on the upper and lower slope Gulf of Alaska from Dixon Entrance to 170°W.

Larvae - No EFH definition determined.
Not applicable (no larval stage)

Juveniles and Adults-Level 0_a
Pelagic waters of the shelf, slope and basin to the seaward edge of the EEZ in the Gulf of Alaska from Dixon Entrance to 170°W. Feeding areas are those containing euphausiids, shrimp, forage fish, and other cephalopods.

EFH Definition for GOA Forage fish complex, Eulachon

Eggs (duration 30-40 days) - Level 0_a
Bottom substrates of sand, gravel and cobble in rivers during April-June.

Larvae (duration 1-2 months) - Level 0_a
Pelagic waters of the inner continental shelf throughout the Gulf of Alaska from Dixon Entrance to 170°W.

Juveniles (to 3 years of age) - Level 0_a
Pelagic waters of the middle and outer continental shelf and upper slope throughout the Gulf of Alaska from Dixon Entrance to 170°W.

Adults (3+ years)- Level 0_a
Pelagic waters of the middle to outer continental shelf and upper slope throughout the Gulf of Alaska from Dixon Entrance to 170°W for non-spawning fishes (July-April). Feeding areas are those containing euphausiids and copepods. Rivers during spawning (April-June).

EFH Definition for GOA Forage fish complex, Capelin

Eggs (duration 2-3 weeks) - Level 0_a
Sand and cobble intertidal beaches down to 10 m depth along the shores of the Gulf of Alaska from Dixon Entrance to 170°W during May-August.

Larvae (duration 4-8 months) - Level 0_a
Epipelagic waters of the inner and middle continental shelf throughout the Gulf of Alaska from Dixon Entrance to 170°W.

Juveniles (1-2 yrs)- Level 0_a

Pelagic waters of the inner and middle continental shelf throughout the Gulf of Alaska from Dixon Entrance to 170°W. May be associated with fronts in winter.

Adults(2+ yrs)- Level 0_a
Pelagic waters of the inner, middle and outer continental shelf throughout the Gulf of Alaska from Dixon Entrance to 170°W during their non-spawning cycle (September-April). Populations associated with fronts in winter. Intertidal beaches of sand and cobble down to 10 m depth during spawning (May-August).

<u>EFH Definition for GOA Forage fish complex, Sand lance</u>

Eggs (3-6 weeks) - Level 0_a
Bottom substrate of sand to sandy gravel along the inner continental shelf throughout the Gulf of Alaska from Dixon Entrance to 170°W.

Larvae (100-131 days) - Level 0_a
Pelagic and neustonic waters along the inner continental shelf throughout the Gulf of Alaska from Dixon Entrance to 170°W.

Juveniles - Level 0_a
Soft bottom substrates (sand, mud) and the entire water column of the inner and middle continental shelf throughout the Gulf of Alaska from Dixon Entrance to 170°W. Feeding areas contain zooplankton, calanoid copepods, mysid shrimps crustacean larvae, gammarid amphipods and chaetognaths.

Adults- Level 0_a
Soft bottom substrates (sand, mud) and the entire water column of the inner and middle continental shelf throughout the Gulf of Alaska from Dixon Entrance to 170°W. Feeding areas contain zooplankton, calanoid copepods, mysid shrimps crustacean larvae, gammarid amphipods and chaetognaths.

<u>EFH Definition for GOA Forage fish complex, Myctophids and Bathylagids</u>

Eggs - Level 0_c - No EFH definition determined
No information available at this time.

Larvae - Level 0_c - No EFH definition determined
No information available at this time.

Juveniles - Level 0_a
Pelagic waters ranging from near surface to lower portion of water column of the slope and basin regions throughout the Gulf of Alaska from Dixon Entrance to 170°W and to the seaward extent of the EEZ.

Adults- Level 0_a
Pelagic waters ranging from near surface to lower portion of water column of the slope and basin regions throughout the Gulf of Alaska from Dixon Entrance to 170°W and to the seaward extent of the EEZ.

EFH Definition for GOA Forage fish complex, Sand fish

Eggs - Level 0_a
Egg masses attached to rock in nearshore areas throughout the Gulf of Alaska from Dixon Entrance to 170°W.

Larvae - Level 0_c - No EFH definition determined
No information available at this time.

Juveniles - Level 0_a
Bottom substrates of mud and sand of the inner continental shelf throughout the Gulf of Alaska from Dixon Entrance to 170°W.

Adults- Level 0_a
Bottom substrates of mud and sand of the inner continental shelf throughout the Gulf of Alaska from Dixon Entrance to 170°W.

EFH Definition for GOA Forage fish complex, Euphausiids

Eggs - Level 0_a
Neustonic waters throughout the Gulf of Alaska from Dixon Entrance to 170°W and to the seaward extent of the EEZ in spring.

Larvae - Level 0_a
Epipelagic waters throughout the Gulf of Alaska from Dixon Entrance to 170°W and to the seaward extent of the EEZ in spring.

Juveniles - Level 0_a
Pelagic waters throughout the Gulf of Alaska from Dixon Entrance to 170°W and to the seaward extent of the EEZ. Dense populations are associated with upwelling or nutrient-rich areas, such as the edge of the continental shelf, heads of submarine canyons, edges of gullies on the continental shelf, in island passes in the Aleutian Islands and over submerged seamounts.

Adults- Level 0_a
Pelagic waters throughout the Gulf of Alaska from Dixon Entrance to 170°W and to the seaward extent of the EEZ. Dense populations are associated with upwelling or nutrient-rich areas, such as the edge of the continental shelf, heads of submarine canyons, edges of gullies on the continental shelf, in island passes in the Aleutian Islands, and over submerged seamounts.

EFH Definition for GOA Forage fish complex, Pholids and Stichaeids

Eggs - Level 0_c - No EFH definition determined
No information available at this time.

Larvae - Level 0_c - No EFH definition determined
No information available at this time.

Juveniles - Level 0_a
Intertidal to demersal waters of the inner continental shelf with mud substrate throughout the Gulf of Alaska from Dixon Entrance to 170°W. Certain species are associated with vegetation such as eelgrass and kelp.

Adults- Level 0_a
Intertidal to demersal waters of the inner continental shelf with mud substrate throughout the Gulf of Alaska from Dixon Entrance to 170°W. Certain species are associated with vegetation such as eelgrass and kelp.

EFH Definition for GOA Forage fish complex, Gonostomatids

Eggs - Level 0_c - No EFH definition determined
No information is available at this time.

Larvae - Level 0_c - No EFH definition determined
No information is available at this time.

Juveniles - Level 0_c - No EFH definition determined
No information is available at this time.

Adults- Level 0_a
Bathypelagic waters throughout the Gulf of Alaska from Dixon Entrance to 170°W and to the seaward extent of the EEZ.

Figure 6.1 Geographic references used in the descriptions and identification of EFH for groundfish in the GOA and BSAI. **(See table of contents for map)**

Figure 6.2 NMFS management areas for the GOA and BSAI regions. **(See table of contents for map)**

See table of contents for the following tables:
Table 6.1 Summary of habitat associations for groundfish in the BSAI and GOA.

Table 6.2 Summary of biological associations for groundfish in the BSAI and GOA.

Table 6.3 Summary of reproductive traits for groundfish in the BSAI and GOA.

See table of contents for the following maps:

Walleye Pollock (eggs)

Walleye Pollock (larvae)

Walleye Pollock (juveniles)

Walleye Pollock (adults)

Pacific Cod (adults and late juveniles)

Dover Sole (adults and late juveniles)

Yellowfin Sole (adults and late juveniles)

Rock Sole (adults and late juveniles)

Rex Sole (adults and late juveniles)

Flathead Sole (adults and late juveniles)

Arrowtooth Flounder (adults and late juveniles)

Sablefish (adults and late juveniles)

Pacific Ocean Perch (adults and late juveniles)

Shortraker and Rougheye Rockfish (adults and late juveniles)

Northern Rockfish (adults and late juveniles)

Dusky Rockfish (adults and late juveniles)

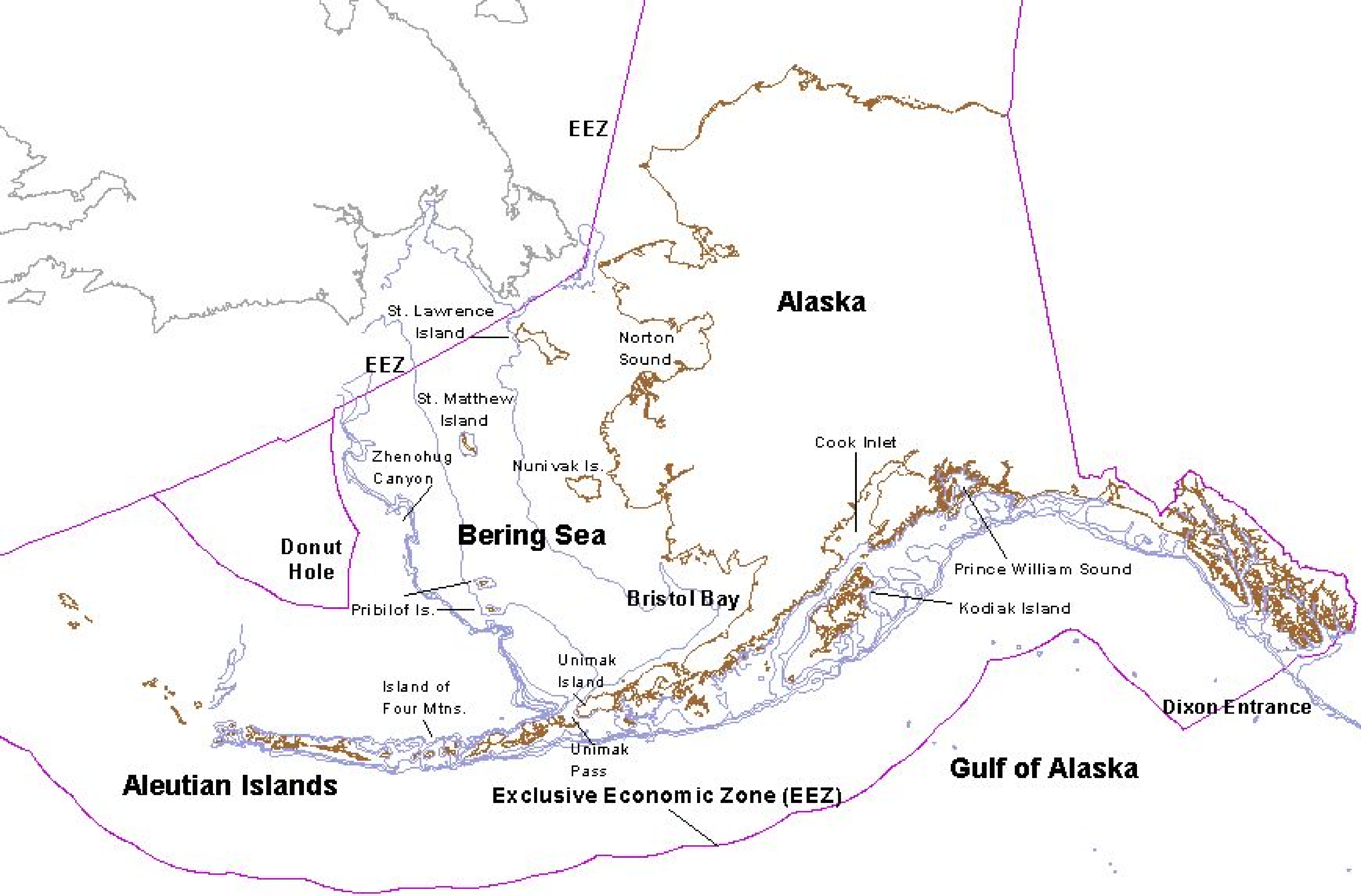
Yelloweye Rockfish (adults and late juveniles)

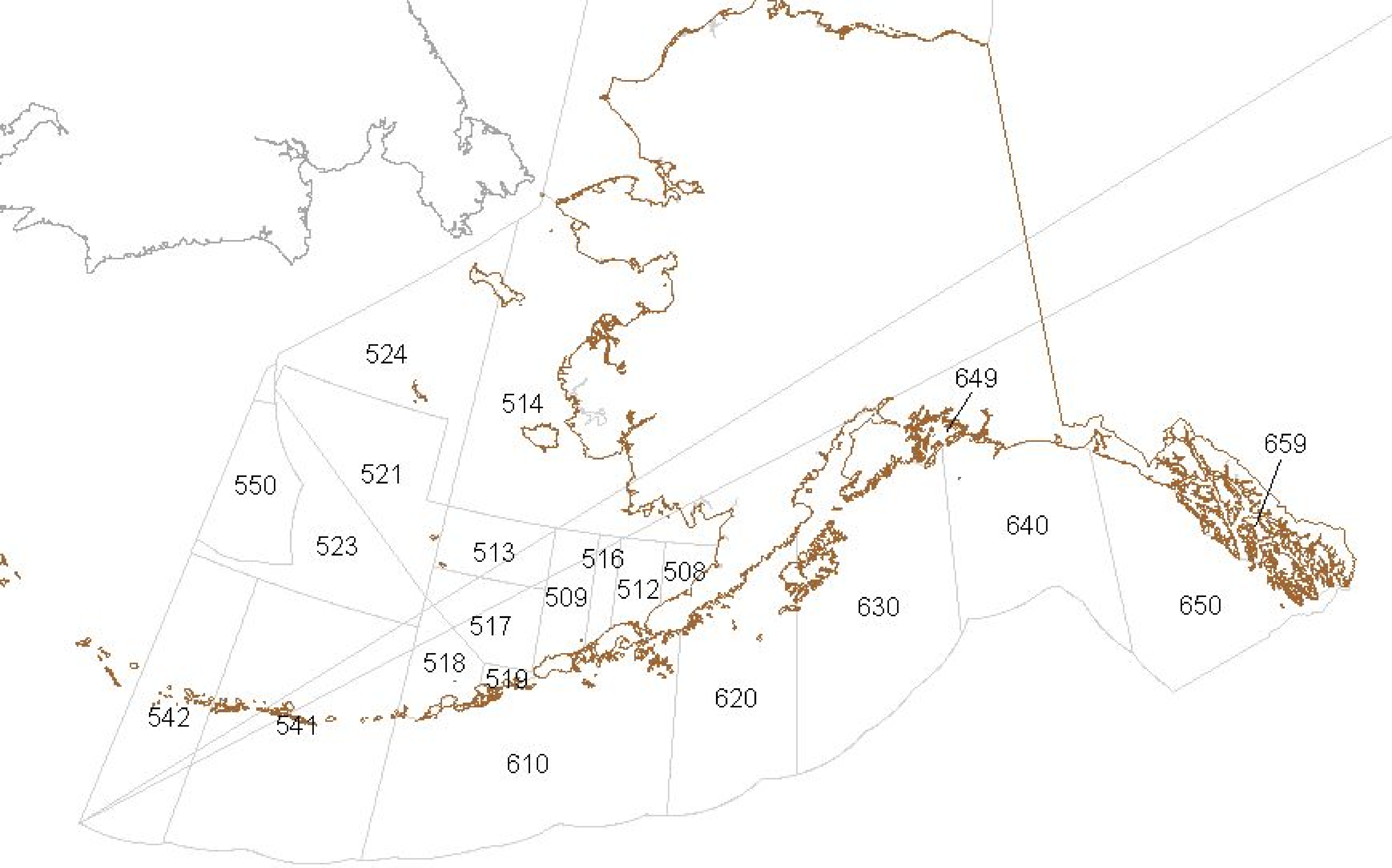
Thornyhead Rockfish (adults and late juveniles)

Atka Mackerel (adults and late juveniles)

Sculpins spp. (adults and late juveniles)

Skates spp. (adults and late juveniles)


EEZ
EEZ
Alaska
St. Lawrence
Island
Norton
Sound
St. Matthew
Island
Zhenohug
Canyon
Nunivak Is.
Cook Inlet
Bering Sea
Donut
Hole
Prince William Sound
Pribilof Is.
Bristol Bay
Kodiak Island
Unimak
Island
Island of
Four Mtns.
Dixon Entrance
Unimak
Pass
Aleutian Islands
Gulf of Alaska
Exclusive Economic Zone (EEZ)


524
514
550
521
523
513
516
508
509
512
517
518
519
542
541
610
620
630
640
649
659
650

	Reproductive Traits																							
	Age at Maturity				Fertilization/Egg Development					Spawning Behavior						Spawning Season								
	Female		Male																					
	50%	100%	50%	100%	External	Internal	Oviparous	Ovoviviparous	Viviparous	Batch Spawner	Broadcast Spawner	Egg Case Deposition	Nest Builder	Egg/Young Guarder	Egg/Young Bearer	Early Spring	Late Spring	Early Summer	Late Summer	Early Fall	Late Fall	Early Winter	Late Winter	Not Known
Walleye pollock	4 yrs		4 yrs		X						X					X								
Pacific cod	5 yrs		5 yrs		X					X						X						X	X	
Yellowfin sole	10.5yrs.				X						X						X	X	X					
Greenland turbot	5-10yrs.				X						X									X	X	X	X	
Arrowtooth flounder	5 yrs		4 yrs		X																			X
Rock sole	9yrs.				X					X						X							X	
Dover sole	33cm				X											X	X					X	X	
Alaska plaice	6-7yrs				X											X								
Rex sole	24cm		16cm		X											X	X	X					X	
Flathead sole					X											X								
Sablefish	65cm		57cm		X						X					X	X							
Pacific ocean perch	10.5 yrs					X			X												X	X		
Shortraker/Rougheye rockfish	20 yrs		20 yrs			X			X								X	X						
Northern rockfish	12.8 yrs					X			X								X	X						
Dusky rockfish						X			X								X	X						
Yelloweye rockfish	22 yrs		22 yrs			X			X								X	X						
Thornyhead rockfish	12 yrs									X						X							X	
Atka mackerel	3 yrs		3 yrs		X								X	X				X	X					
Squid						X											X	X						
Capelin	2 yrs	4 yrs	2 yrs	4 yrs	X						X						X	X	X					
Eulachon	3 yrs	5 yrs	3 yrs	5 yrs	X					X							X							
Sculpins					X	X							X	X								X	X	
Sharks						X		X																
Skates						X	X					X												X
Octopus						X																		X

Table 3. Summary of Reproductive traits for Groundfish in the BSAI and GOA.

		BIOLOGICAL ATTRIBUTES																							
		Feeding Type						Movements					Social Behavior				Longevity of Life Stage								
	Life Stage/Activity	Carnivore	Herbivore	Omnivore	Planktivore	Detritivore	Not Known	Drift With Ocean Conditions	Reside in Nursery Areas	Alongshore Migrations	Inshore/Offshore Migrations	Not Known	Solitary	Schooling	Shoaling	Not Known	1 Day	1 - 30 Days	1 - 12 Months	1 - 5 Years	5 - 20 Years	20 - 50 Years	> 50 Years	Not Known	Life Stage/Activity
Walleye pollock	A	X						X						X							X				A
	J	X						X						X						X					J
	L				X			X								X			X						L
	E							X										X							E
Pacific cod	A	X										X		X							X				A
	LJ	X						X								X				X					LJ
	EJ	X						X								X			X						EJ
	L				X			X								X								X	L
	E								X									X							E
Yellowfin sole	A	X									X					X					X				A
	LJ	X										X				X				X					LJ
	EJ	X										X				X				X					EJ
	L				X							X				X			X						L
	E											X				X								X	E
Greenland turbot	A	X									X					X					X				A
	LJ	X										X				X					X				LJ
	EJ						X					X				X				X					EJ
	L				X							X				X			X						L
	E											X				X								X	E
Arrowtooth flounder	A	X									X					X				X					A
	LJ	X										X				X				X					LJ
	EJ	X										X				X				X					EJ
	L				X							X				X			X						L
	E											X				X								X	E
Rock sole	A	X									X					X					X				A
	LJ	X										X				X					X				LJ
	EJ	X										X				X				X					EJ
	L				X							X				X			X						L
	E											X				X								X	E
Dover sole	A	X																			X				A
	LJ	X																		X					LJ
	EJ	X																		X					EJ
	L				X			X								X			X						L
	E											X				X								X	E

Table 2. Summary of Biological associations for Groundfish in the BSAI and GOA.

		BIOLOGICAL ATTRIBUTES																							
		Feeding Type						Movements					Social Behavior				Longevity of Life Stage								
	Life Stage/Activity	Carnivore	Herbivore	Omnivore	Planktivore	Detritivore	Not Known	Drift With Ocean Conditions	Reside in Nursery Areas	Alongshore Migrations	Inshore/Offshore Migrations	Not Known	Solitary	Schooling	Shoaling	Not Known	1 Day	1 - 30 Days	1 - 12 Months	1 - 5 Years	5 - 20 Years	20 - 50 Years	> 50 Years	Not Known	Life Stage/Activity
Alaska plaice	A	X										X				X					X				A
	J	X										X				X					X				J
	L				X							X				X			X						L
	E											X				X								X	E
Rex sole	A	X										X				X				X					A
	J	X										X				X				X					J
	L				X							X				X								X	L
	E											X				X								X	E
Flathead sole	A	X									X					X								X	A
	LJ	X										X				X								X	LJ
	EJ	X										X				X								X	EJ
	L				X			X								X								X	L
	E											X				X								X	E
Sablefish	A	X										X				X						X			A
	LJ	X										X				X				X					LJ
	EJ	X									X					X				X					EJ
	L				X			X								X			X						L
	E							X								X		X							E
Pacific Ocean perch	A	X									X			X									X		A
	J	X										X				X					X				J
	L				X							X				X			X						L
Shortraker/rougheye rockfish	A	X										X				X							X		A
	J	X										X				X								X	J
	L						X					X				X								X	L
Northern rockfish	A	X										X		X									X		A
	J						X					X				X					X				J
	L						X					X				X								X	L
Dusky rockfish	A	X										X				X						X			A
	J						X					X				X								X	J
	L						X					X				X								X	L
Yelloweye rockfish	A	X										X	X										X		A
	J						X					X	X								X				J
	L				X							X				X			X						L
Thornyhead rockfish	A	X										X				X								X	A
	J	X										X				X								X	J
	L						X					X				X			X						L
	E						X					X				X								X	E

Table 2. Summary of Biological associations for Groundfish in the BSAI and GOA.

		BIOLOGICAL ATTRIBUTES																							
		Feeding Type						Movements					Social Behavior				Longevity of Life Stage								
	Life Stage/Activity	Carnivore	Herbivore	Omnivore	Planktivore	Detritivore	Not Known	Drift With Ocean Conditions	Reside in Nursery Areas	Alongshore Migrations	Inshore/Offshore Migrations	Not Known	Solitary	Schooling	Shoaling	Not Known	1 Day	1 - 30 Days	1 - 12 Months	1 - 5 Years	5 - 20 Years	20 - 50 Years	> 50 Years	Not Known	Life Stage/Activity
Atka mackerel	A	X									X			X						X					A
	J	X										X				X				X					J
	L	X										X				X			X						L
	E				X							X				X		X							E
Squid	A	X									X					X				X					A
	J				X							X				X			X						J
	E						X					X				X			X						E
Capelin	A	X									X			X						X					A
	J	X										X				X				X					J
	L				X							X				X			X						L
	E											X				X		X							E
Eulachon	A	X									X			X						X					A
	J	X										X				X				X					J
	L				X							X				X			X						L
	E											X				X		X							E
Sculpins	A	X										X				X								X	A
	J	X										X				X								X	J
	L						X					X				X								X	L
	E						X					X				X								X	E
Sharks	A	X										X				X							X		A
	J	X										X				X								X	J
	L						X					X				X								X	L
	E						X					X				X								X	E
Skates	A	X										X				X								X	A
	J	X										X				X								X	J
	E											X				X								X	E
Octopus	A	X										X				X				X					A
	J				X							X				X								X	J
	E											X				X								X	E

Table 2. Summary of Biological associations for Groundfish in the BSAI and GOA.

		HABITAT ASSOCIATIONS																														
		Location										Substrate								Vegeta-tion		Pelagic Domain					Oceanography					
	Life Stage/Activity	Beach (intertidal)	Inner Shelf (1-50 m)	Middle Shelf (50-100 m)	Outer Shelf (100-200 m)	Upper Slope (200-1000 m)	Lower Slope (>1000m)	Basin (> 3000 m)	Bay/Estuarine	Island pass	Not Known	Mud/Clay/Silt	Sand/Granule	Gravel	Pebble	Cobble	Boulder	Bedrock	Not Applicable	Kelp Forest	Sea Grasses	Near Surface	Pelagic	Semi-demersal/Semi-pelagic	Demersal	Not Known	Upwelling areas	Gyres	Thermo/pycnocline	Fronts	Edges (ice, bathymetric)	Life Stage/Activity
Walleye pollock	A				X			X															X	X			X	X		X	X	A
	J		X	X	X					X									X				X	X				X	X	X		J
	L				X														X				X					X		X		L
	E				X	X		X											X				X					X				E
Pacific cod	A		X	X	X							X	X												X							A
	LJ		X	X	X							X	X												X							LJ
	EJ		X	X								X	X												X							EJ
	L										X								X			X										L
	E		X	X	X							X	X												X							E
Yellowfin sole	A	X	X	X	X				X				X												X						X	A
	LJ		X	X	X				X				X												X							LJ
	EJ		X	X	X				X				X												X							EJ
	L	X	X						X										X				X									L
	E	X							X										X				X									E
Greenland turbot	A				X	X	X					X	X											X	X							A
	LJ		X	X	X	X						X	X											X	X							LJ
	EJ		X	X	X														X							X						EJ
	L		X	X	X														X				X									L
	E			X	X																			X	X							E
Arrowtooth flounder	A		X	X	X	X			X			X	X	X											X						X	A
	LJ		X	X	X	X						X	X	X											X							LJ
	EJ		X	X	X	X						X	X	X											X							EJ
	L		X	X	X				X														X									L
	E		X	X	X																		X									E
Rock sole	A		X	X	X								X	X											X						X	A
	LJ		X	X	X				X				X	X											X							LJ
	EJ		X	X	X				X				X	X											X							EJ
	L		X	X	X																		X									L
	E				X																				X							E
Dover sole	A			X	X	X						X	X												X							A
	LJ		X	X								X	X												X							LJ
	EJ		X	X								X	X												X							EJ
	L		X	X	X	X													X				X									L
	E		X	X	X	X													X				X									E

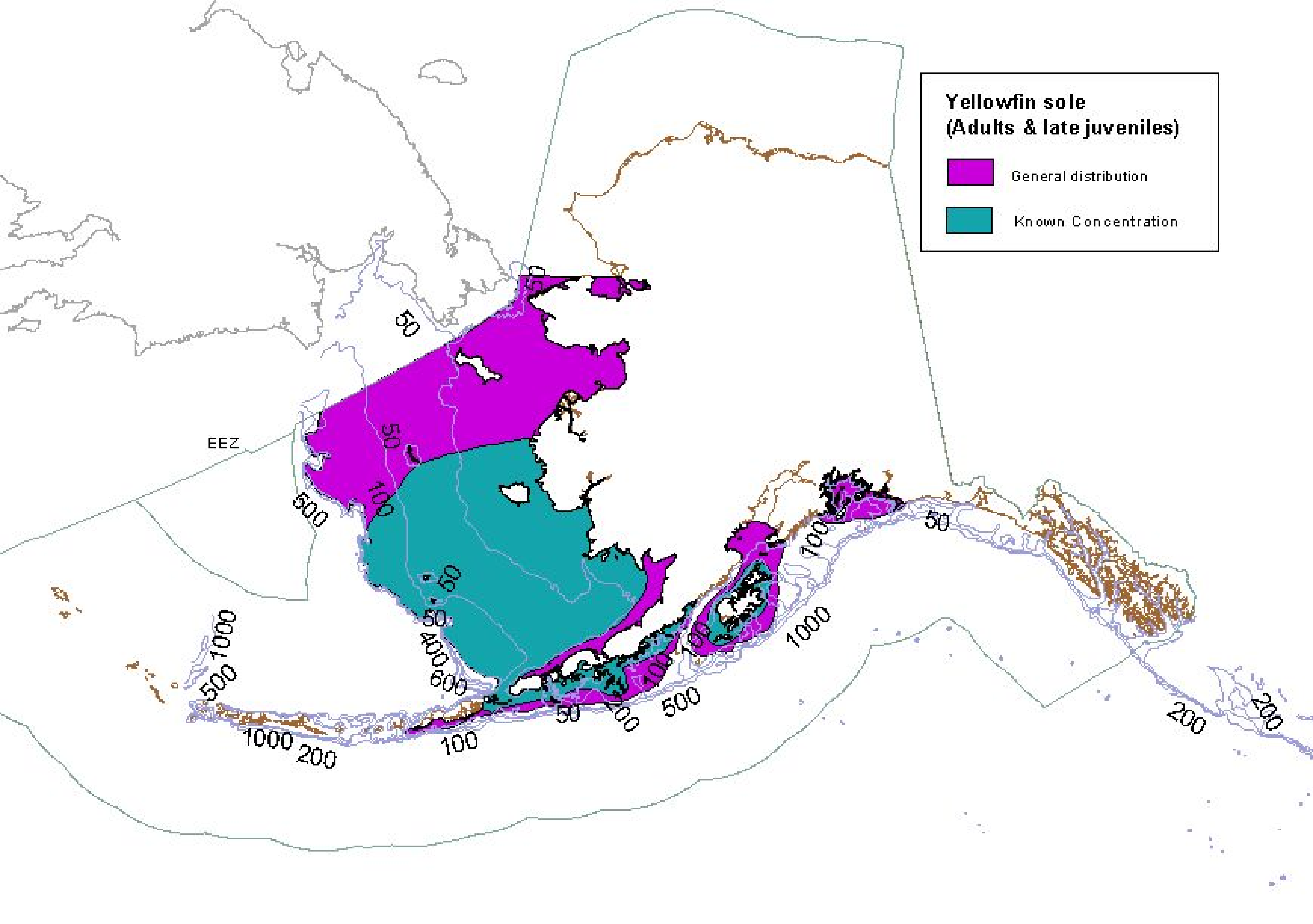
Table 1. Summary of Habitat associations for Groundfish in the BSAI and GOA.

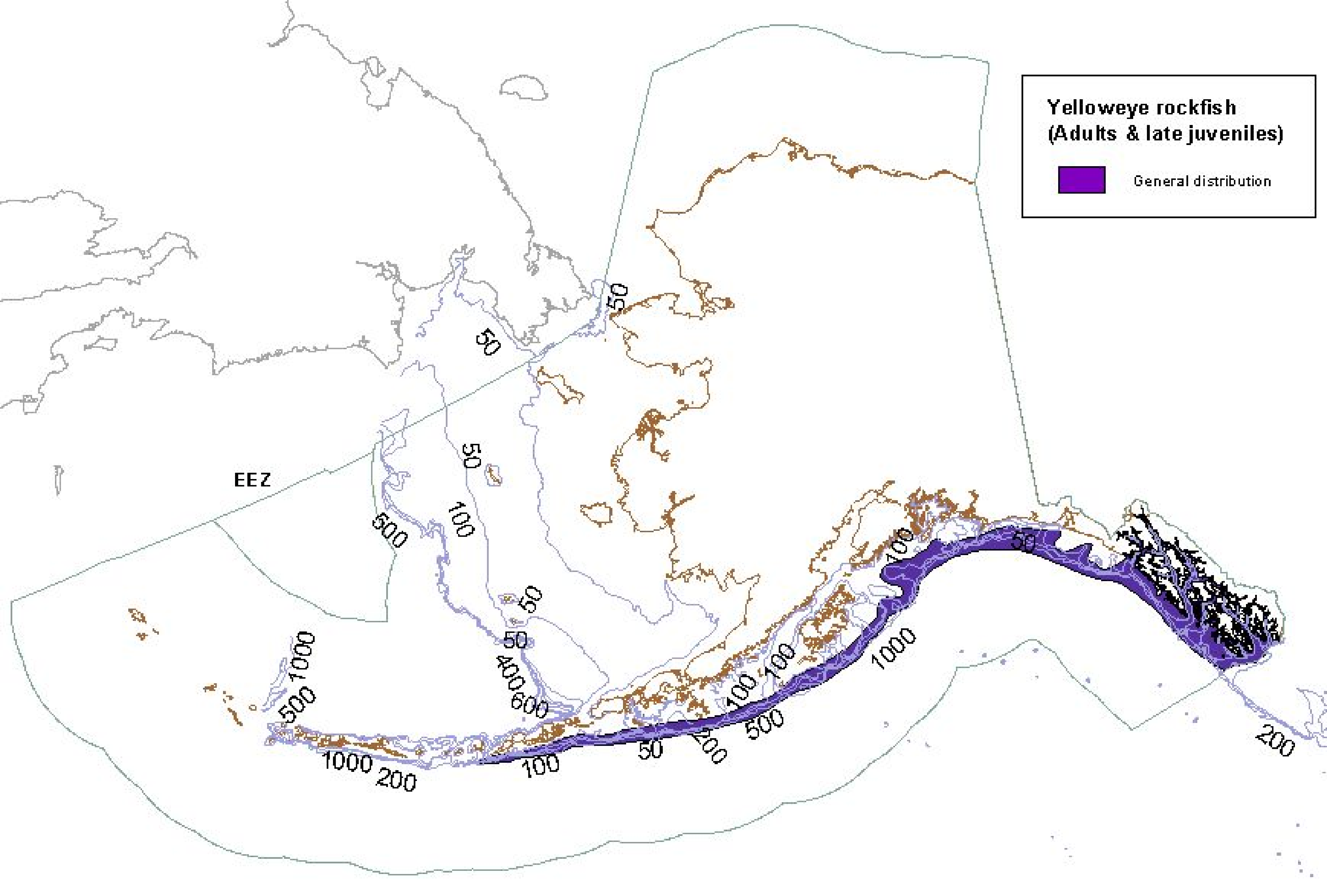
		HABITAT ASSOCIATIONS: Location										Substrate								Vegetation		Pelagic Domain					Oceanography					
	Life Stage/Activity	Beach (intertidal)	Inner Shelf (1-50 m)	Middle Shelf (50-100 m)	Outer Shelf (100-200 m)	Upper Slope (200-1000 m)	Lower Slope (>1000m)	Basin (> 3000 m)	Bay/Estuarine	Island pass	Not Known	Mud/Clay/Silt	Sand/Granule	Gravel	Pebble	Cobble	Boulder	Bedrock	Not Applicable	Kelp Forest	Sea Grasses	Near Surface	Pelagic	Semi-demersal/Semi-pelagic	Demersal	Not Known	Upwelling areas	Gyres	Thermo/pycnocline	Fronts	Edges (ice, bathymetric)	Life Stage/Activity
Alaska plaice	A		X	X								X	X												X							A
	J		X	X								X	X												X							J
	L		X	X																			X									L
	E		X		X																		X									E
Rex sole	A			X	X	X						X	X	X											X							A
	J		X	X	X							X	X	X											X							J
	L		X	X	X														X				X									L
	E		X	X	X														X				X									E
Flathead sole	A		X	X	X							X	X												X						X	A
	LJ		X	X	X							X	X												X							LJ
	EJ		X	X	X							X	X												X							EJ
	L		X	X	X														X				X									L
	E		X	X	X														X				X									E
Sablefish	A					X	X																		X		X					A
	LJ					X	X																		X		X					LJ
	EJ		X	X	X				X	X									X				X	X	X		X					EJ
	L			X	X	X	X	X											X			X					X					L
	E					X	X	X											X				X				X					E
Pacific Ocean perch	A				X	X								X	X	X								X	X		X					A
	J		X	X	X	X								X	X	X	X						X	X			X					J
	L		X	X	X	X	X	X											X				X				X					L
Shortraker & Rougheye rockfish	A				X	X						X	X	X	X	X	X	X						X								A
	J			X	X																					X						J
	L										X								X							X						L
Northern rockfish	A				X	X										X	X							X								A
	J		X	X	X											X	X							X								J
	L										X								X				X									L
Dusky rockfish	A				X	X								X		X	X							X								A
	J		X	X	X									X		X	X									X						J
	L										X								X				X									L

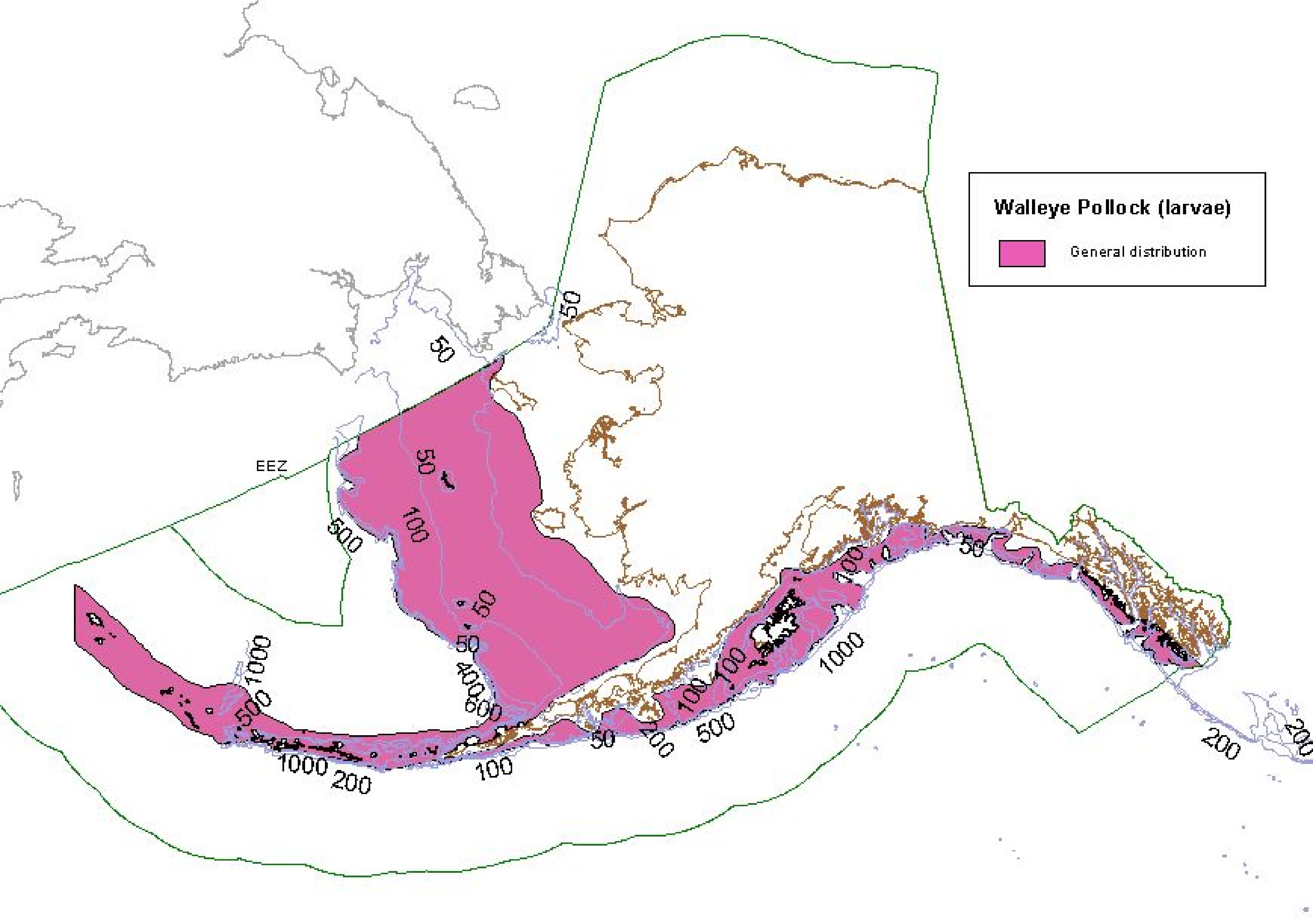
Table 1. Summary of Habitat associations for Groundfish in the BSAI and GOA.

		HABITAT ASSOCIATIONS																														
		Location										Substrate								Veg.		Pelagic Domain					Oceanography					
	Life Stage/Activity	Beach (intertidal)	Inner Shelf (1-50 m)	Middle Shelf (50-100 m)	Outer Shelf (100-200 m)	Upper Slope (200-1000 m)	Lower Slope (>1000m)	Basin (> 3000 m)	Bay/Estuarine	Island pass	Not Known	Mud/Clay/Silt	Sand/Granule	Gravel	Pebble	Cobble	Boulder	Bedrock	Not Applicable	Kelp Forest	Sea Grasses	Near Surface	Pelagic	Semi-demersal/Semi-pelagic	Demersal	Not Known	Upwelling areas	Gyres	Thermo/pycnocline	Fronts	Edges (ice, bathymetric)	Life Stage/Activity
Yelloweye rockfish	A			X	X	X			X	X				X		X	X								X							A
	J			X	X	X			X	X				X		X									X							J
	L										X			X		X									X							L
Thornyhead rockfish	A			X	X	X	X					X	X	X	X	X	X	X							X							A
	J			X	X	X						X	X	X	X	X	X	X							X							J
	L										X												X									L
	E										X												X									E
Atka mackerel	A		X	X	X					X				X	X	X				X				X						X	X	A
	J										X															X						J
	L										X											X										L
	E		X							X				X	X	X				X					X							E
Squid	A		X	X	X	X	X	X																X			X			X		A
	J		X	X	X	X	X	X											X			X	X				X			X		J
	E					X	X					X	X												X							E
Capelin	A	X	X	X	X								X	X									X	X	X					X	X	A
	J		X	X															X				X							X	X	J
	L		X	X															X			X	X									L
	E	X											X			X									X							E
Eulachon	A			X	X	X			X				X			X							X		X					X		A
	J			X	X	X													X				X							X		J
	L		X																X				X									L
	E								X				X			X									X							E
Sculpins	A	X	X	X	X	X						X	X	X											X							A
	J	X	X	X	X	X						X	X	X											X							J
	L		X	X	X	X													X			X	X									L
	E	X	X	X	X									X	X	X									X							E
Sharks	A		X	X	X	X													X				X		X							A
	J		X	X	X	X													X				X		X							J
	L										X								X													L
Skates	A			X	X	X																			X							A
	J			X	X	X																			X							J
	E			X	X	X																			X							E
Octopus	A		X	X	X	X						X	X	X											X							A
	J		X	X	X	X					X													X								J
	E		X	X	X	X					X			X	X	X									X							E

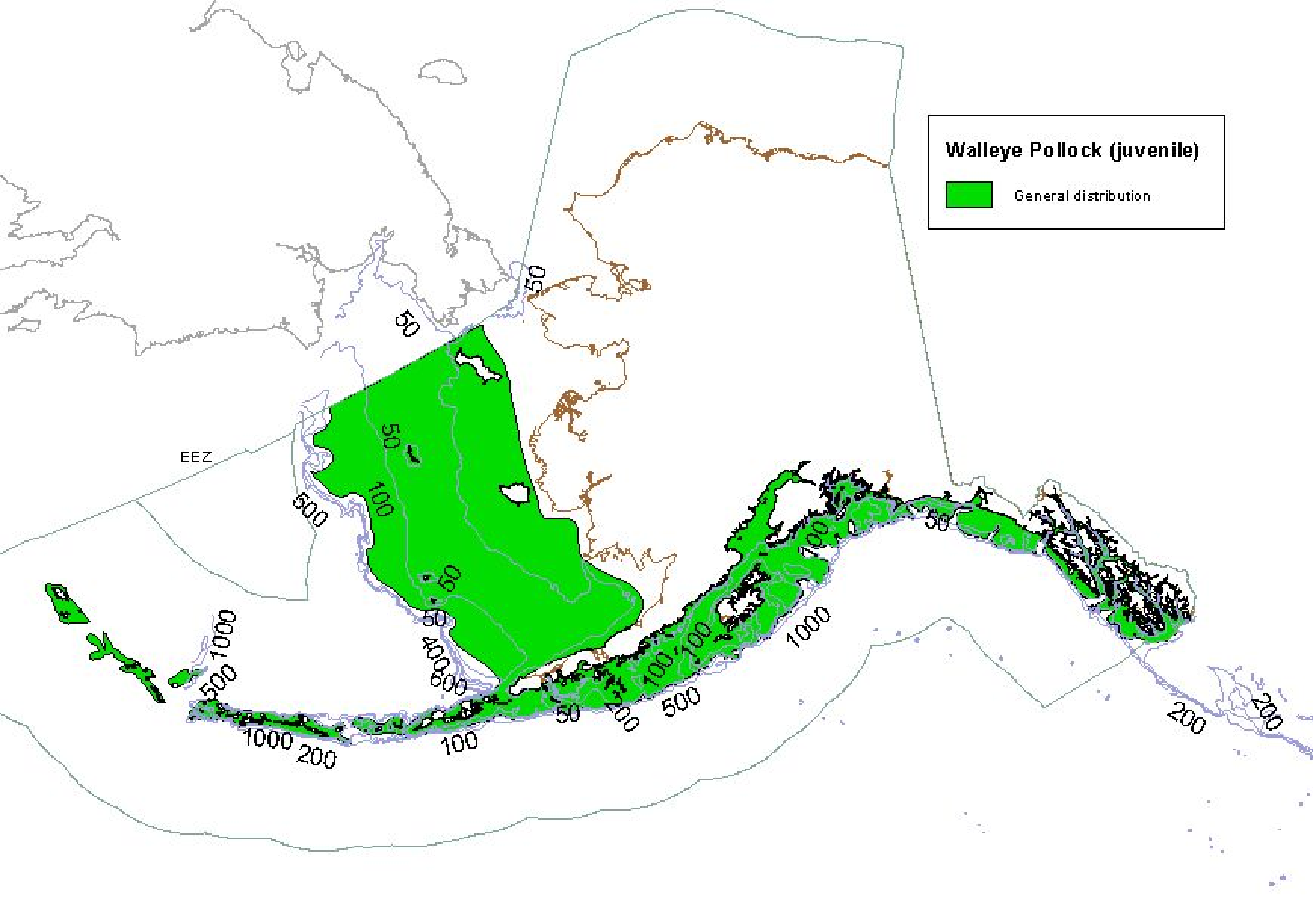
Table 1. Summary of Habitat associations for Groundfish in the BSAI and GOA.


Yellowfin sole
(Adults & late juveniles)
General distribution
Known Concentration
EEZ
50
100
200
400
500
600
1000

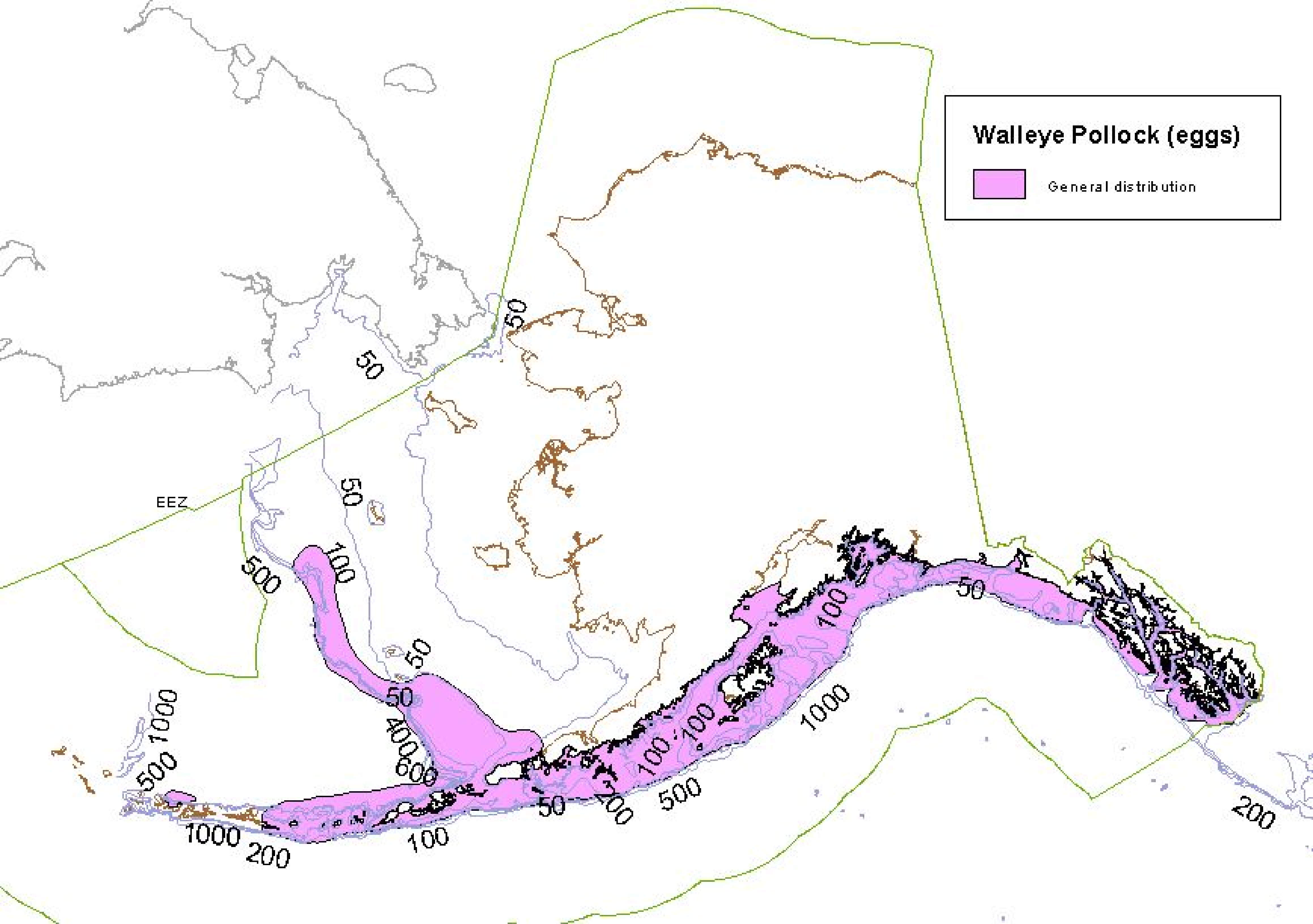

Yelloweye rockfish
(Adults & late juveniles)
General distribution
EEZ
50
100
200
400
500
600
1000

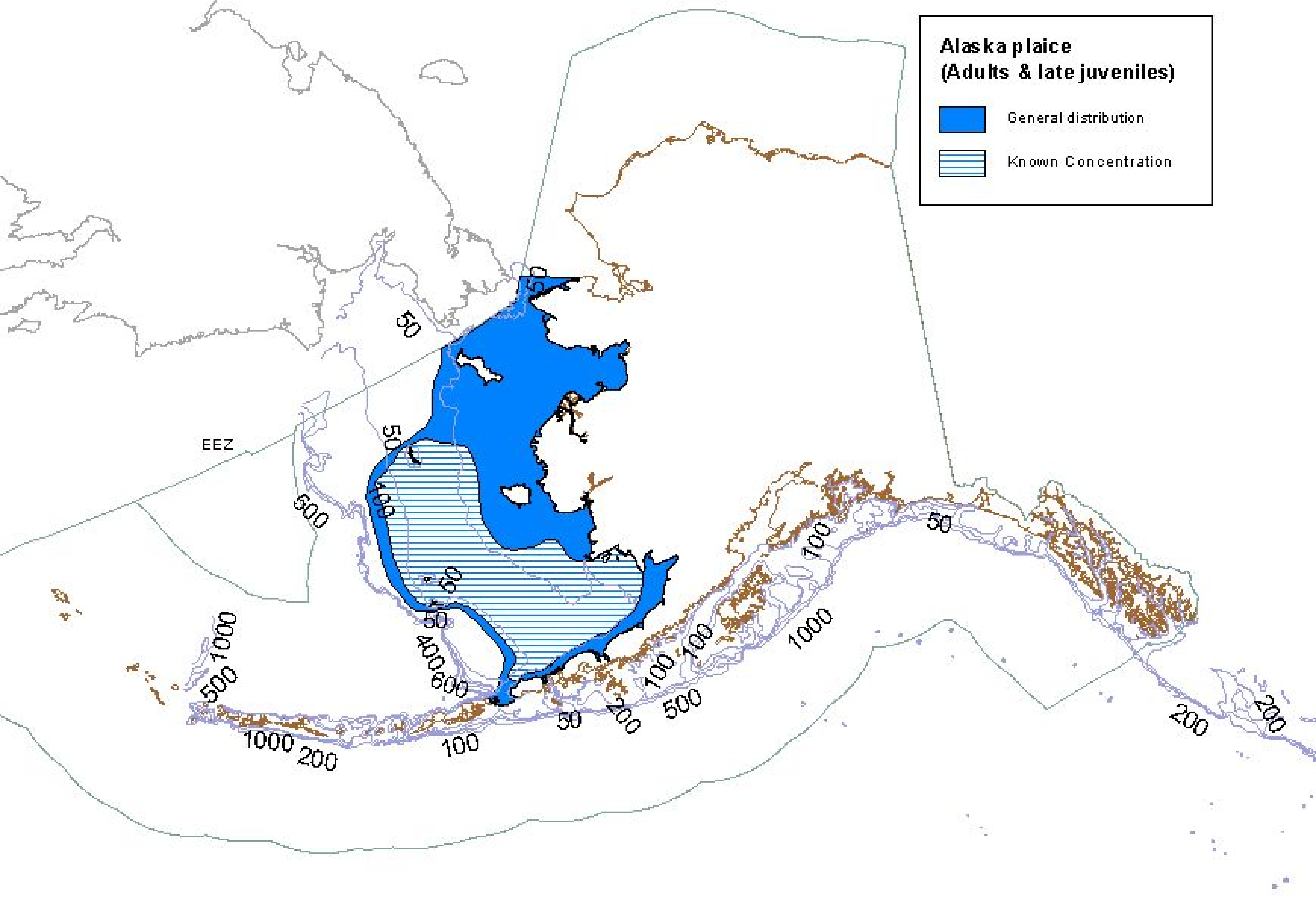


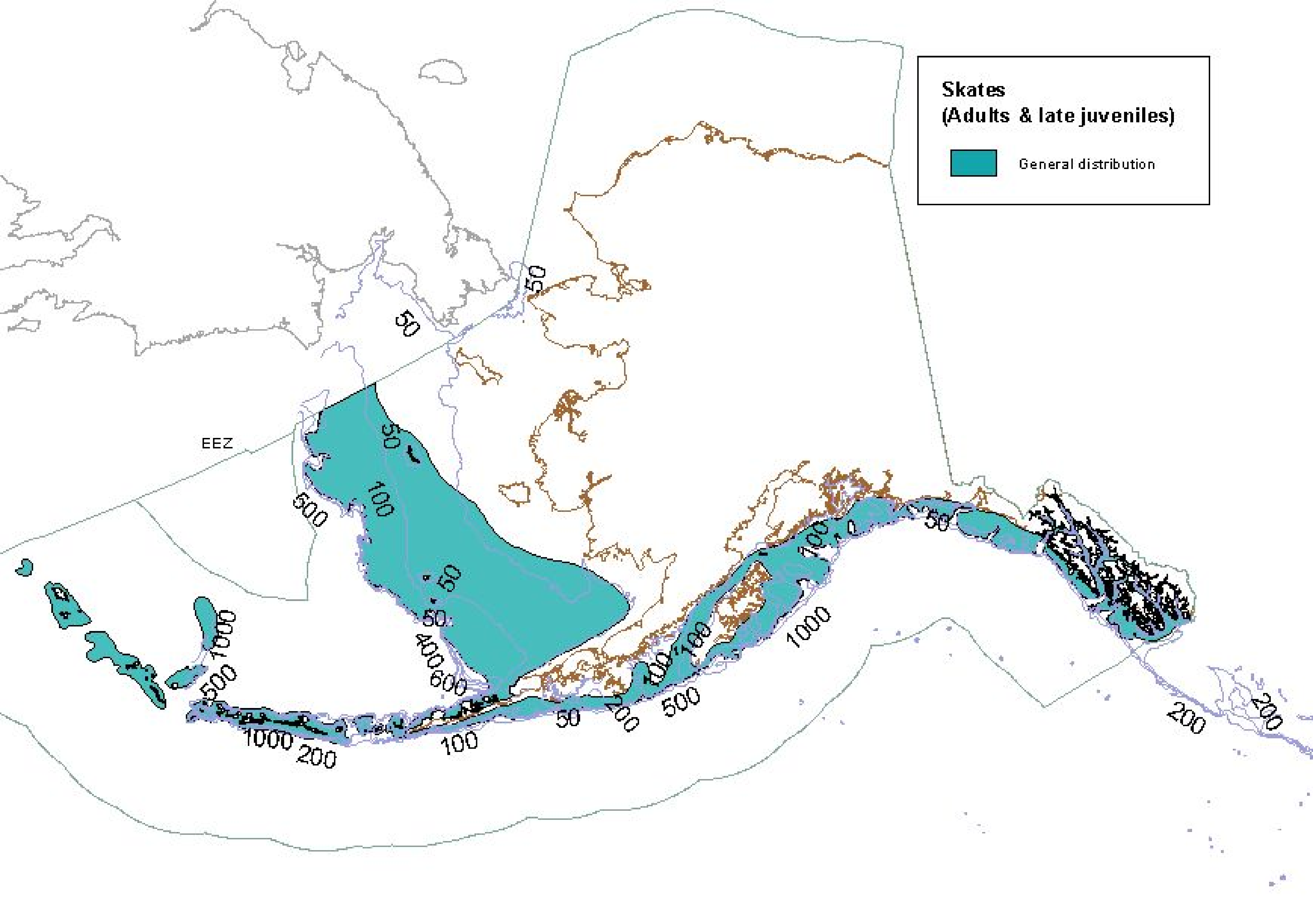
Walleye Pollock (larvae)
General distribution
EEZ
50
100
200
400
500
600
1000

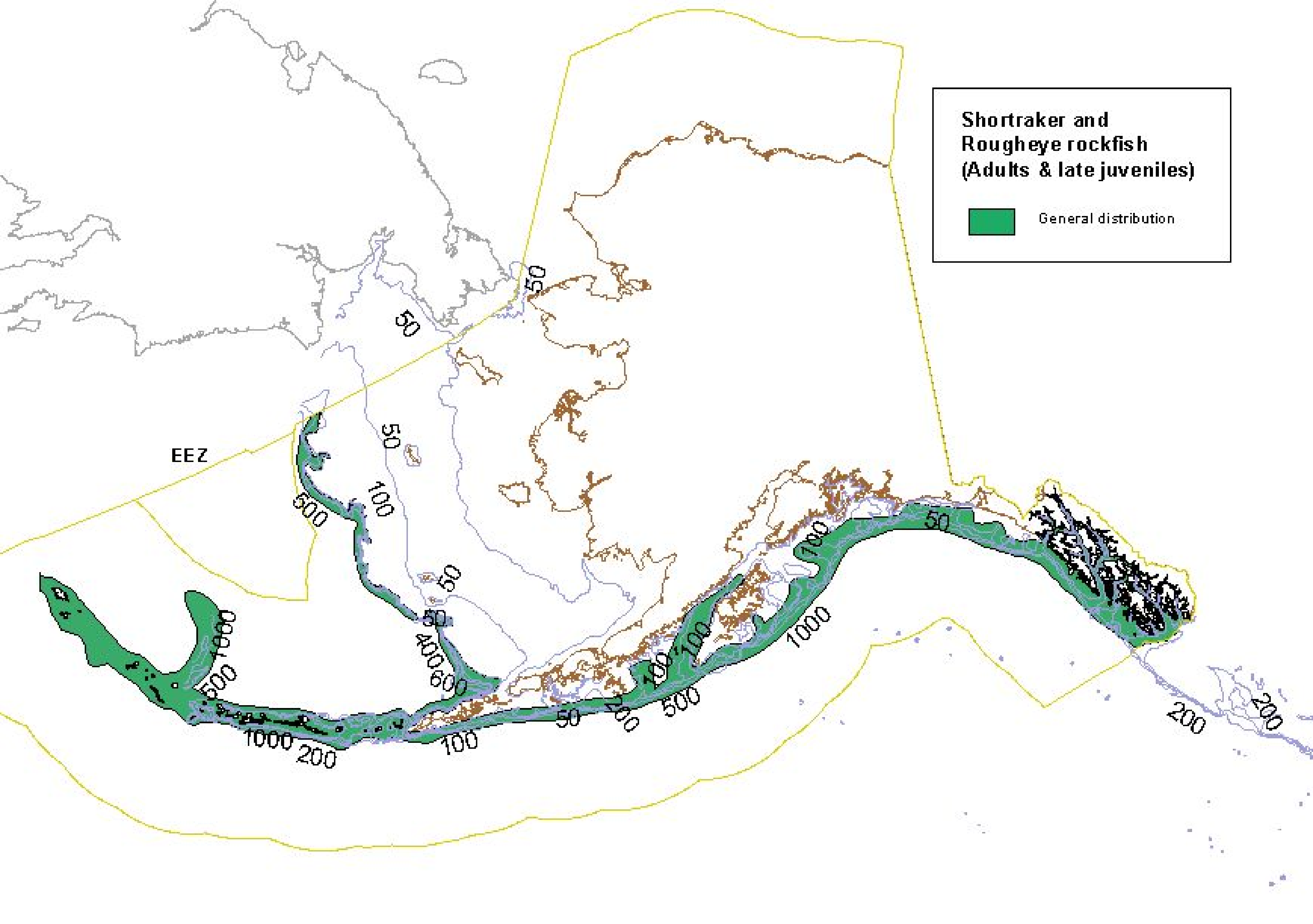


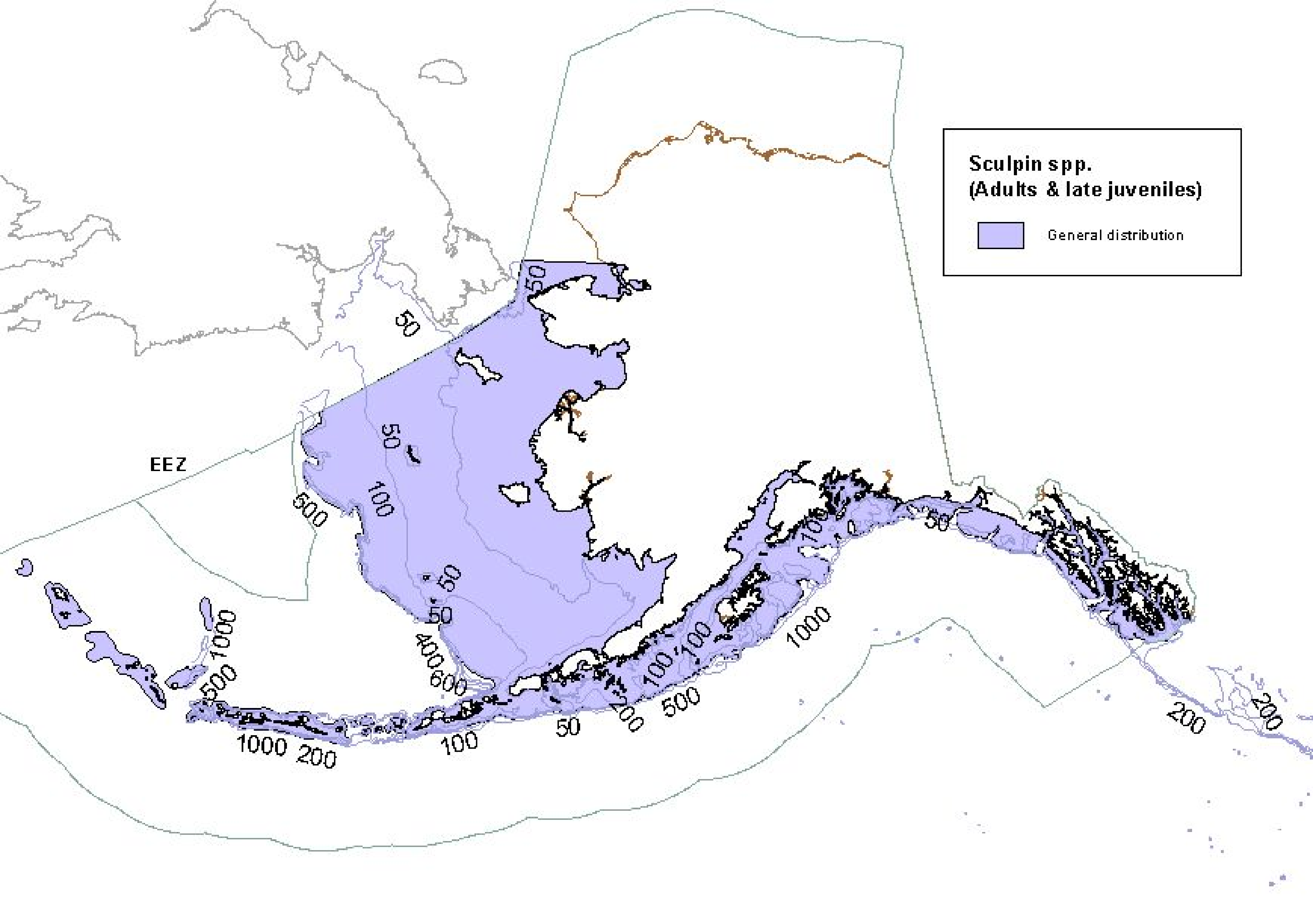
Walleye Pollock (juvenile)
General distribution
EEZ
50
100
200
400
500
600
1000

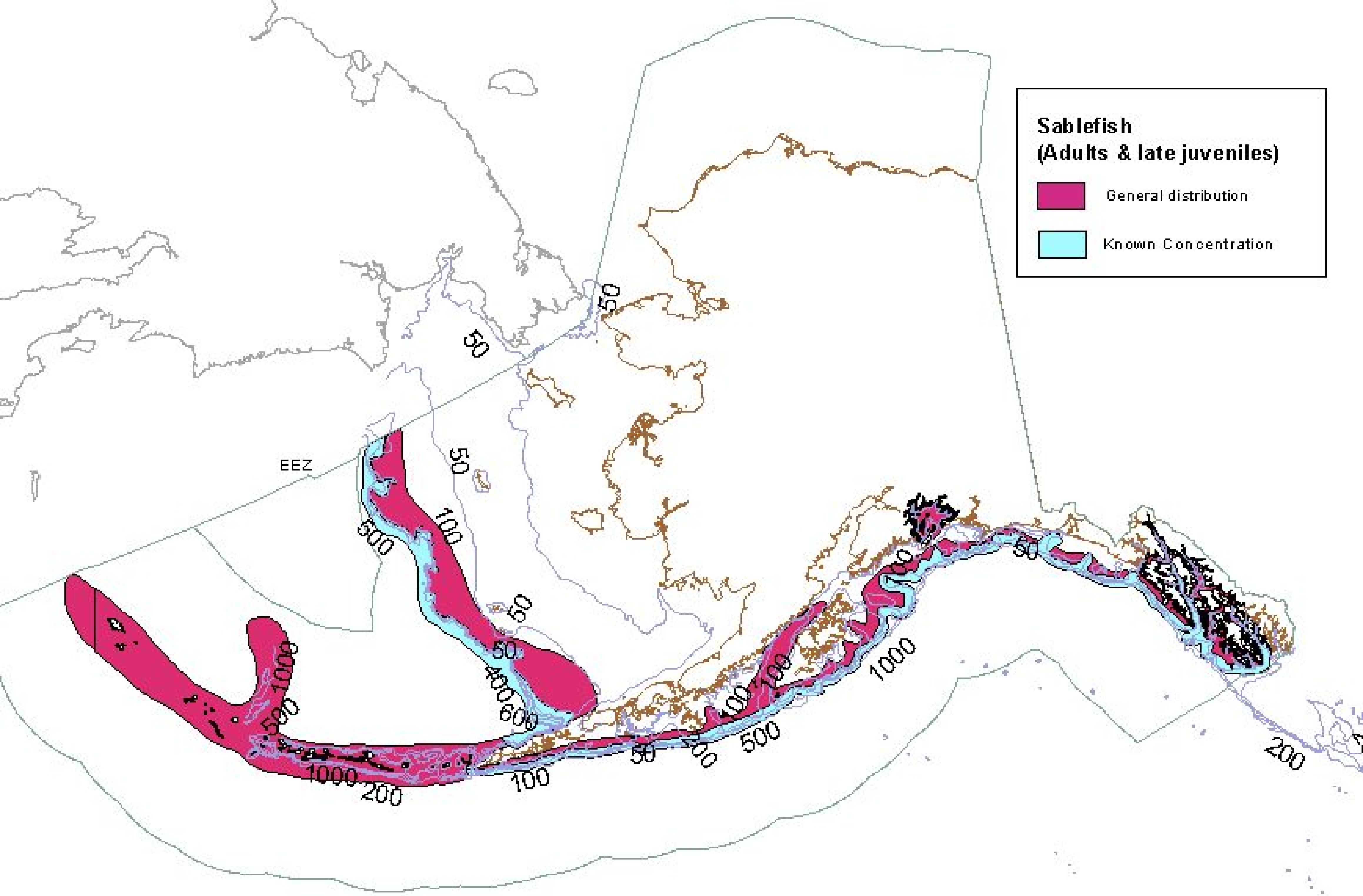

Walleye Pollock (eggs)
General distribution
EEZ
50
100
200
400
500
600
1000


Alaska plaice
(Adults & late juveniles)
General distribution
Known Concentration
EEZ
50
50
50
100
500
50
50
400
600
1000
500
1000
200
100
50
200
500
100
100
100
1000
100
50
200
200

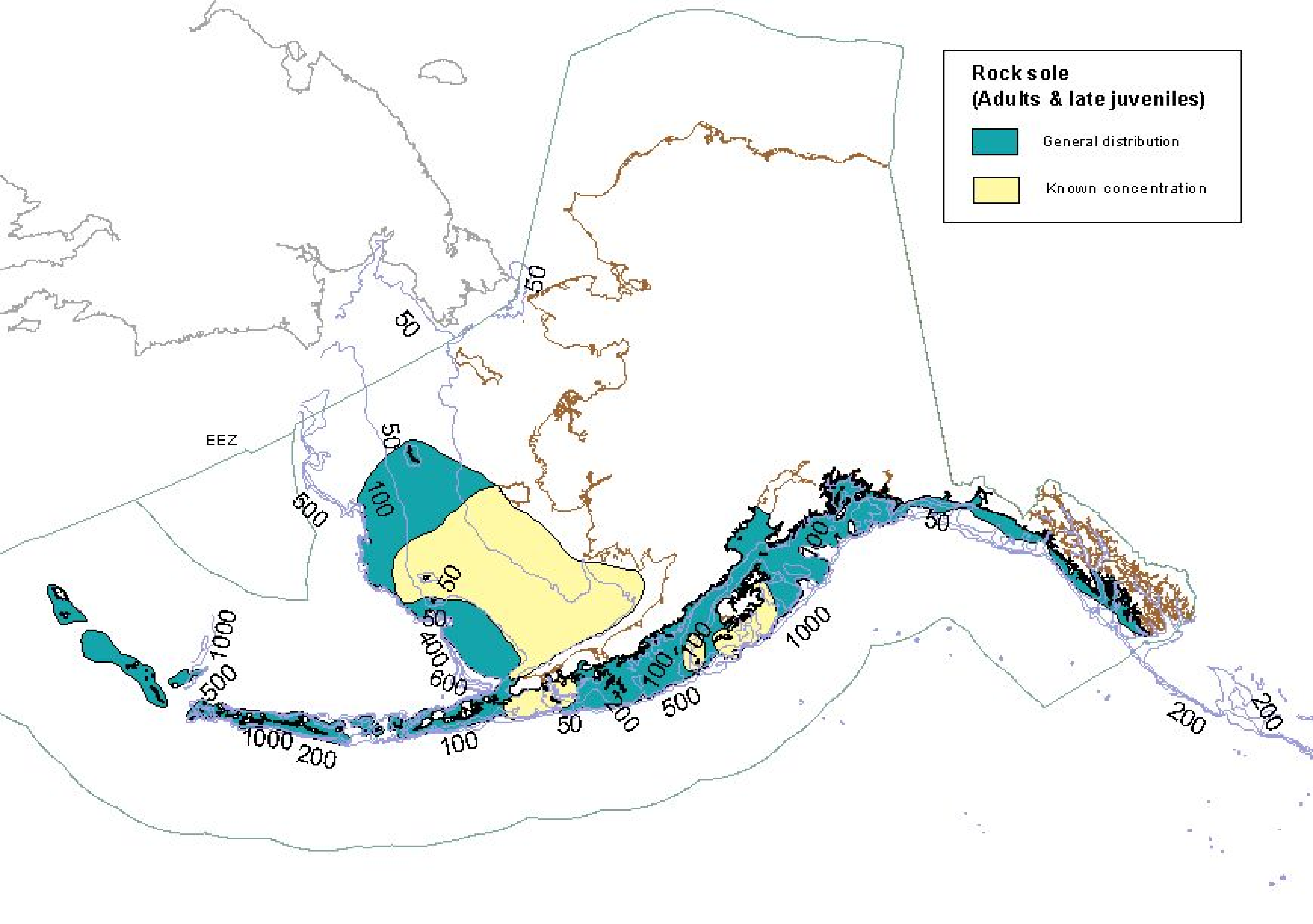

Skates
(Adults & late juveniles)
General distribution
EEZ
50
100
200
400
500
600
1000


Shortraker and
Rougheye rockfish
(Adults & late juveniles)
General distribution
EEZ
50
100
200
400
500
600
1000

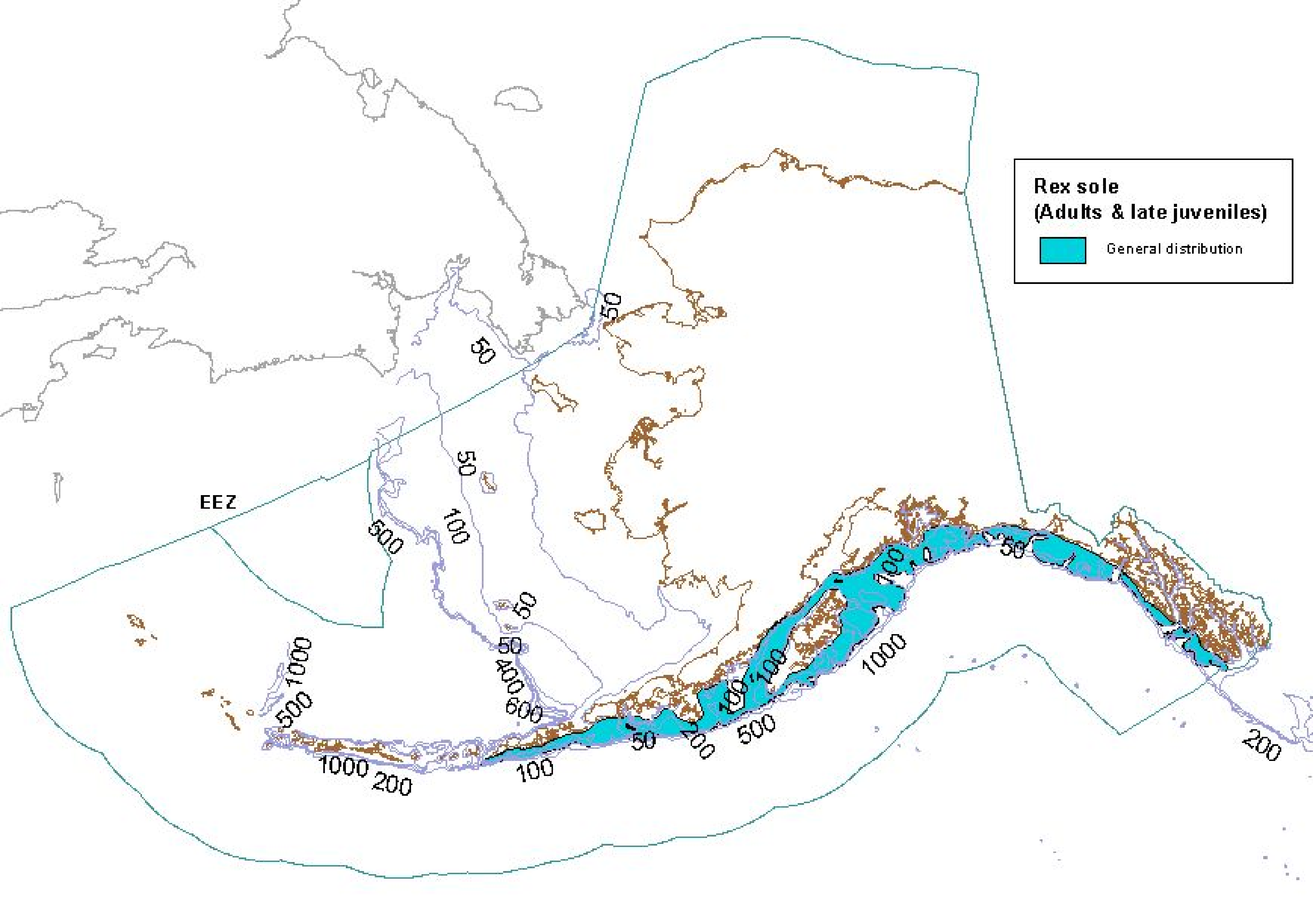

Sculpin spp.
(Adults & late juveniles)
General distribution
EEZ
50
100
200
400
500
600
1000

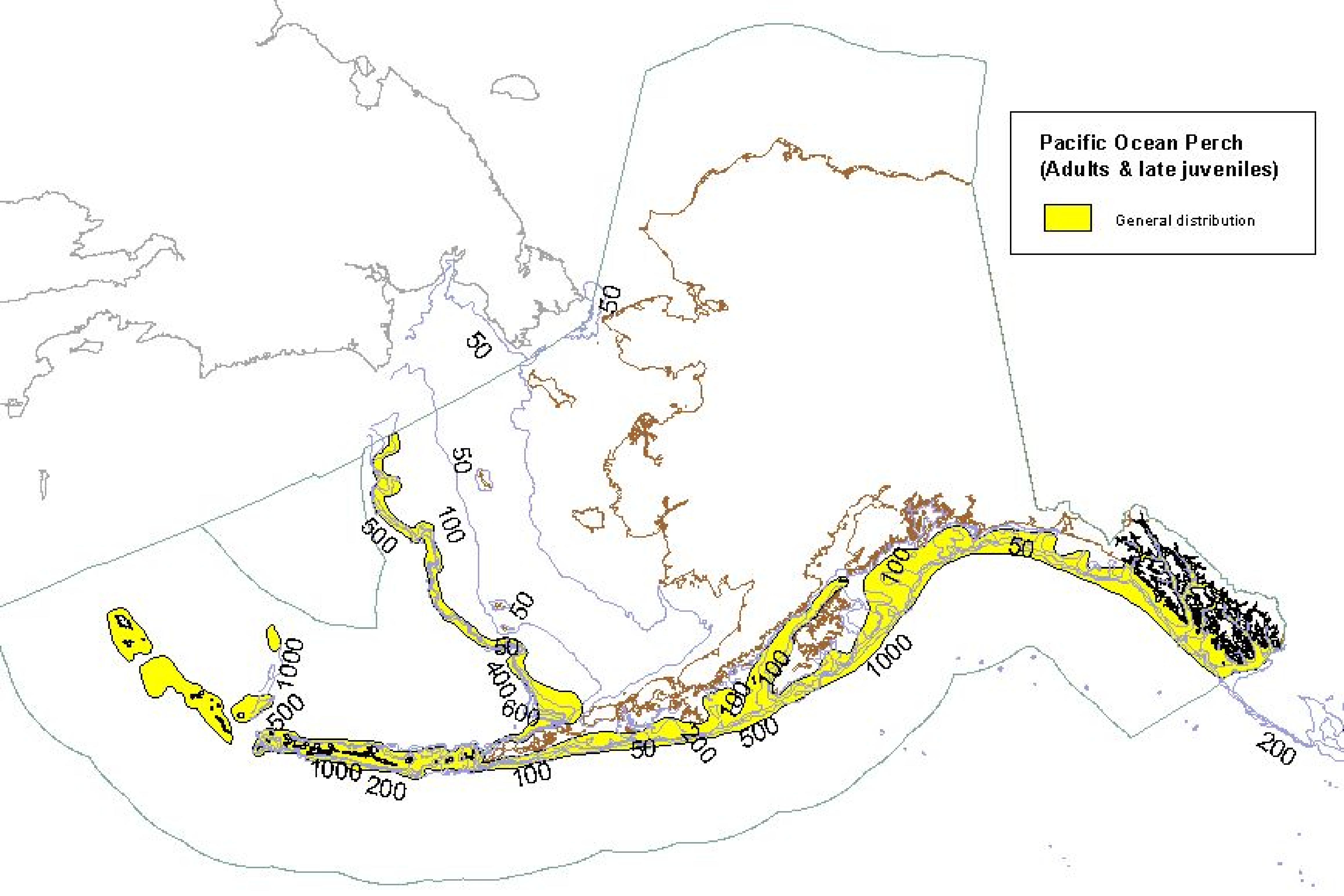


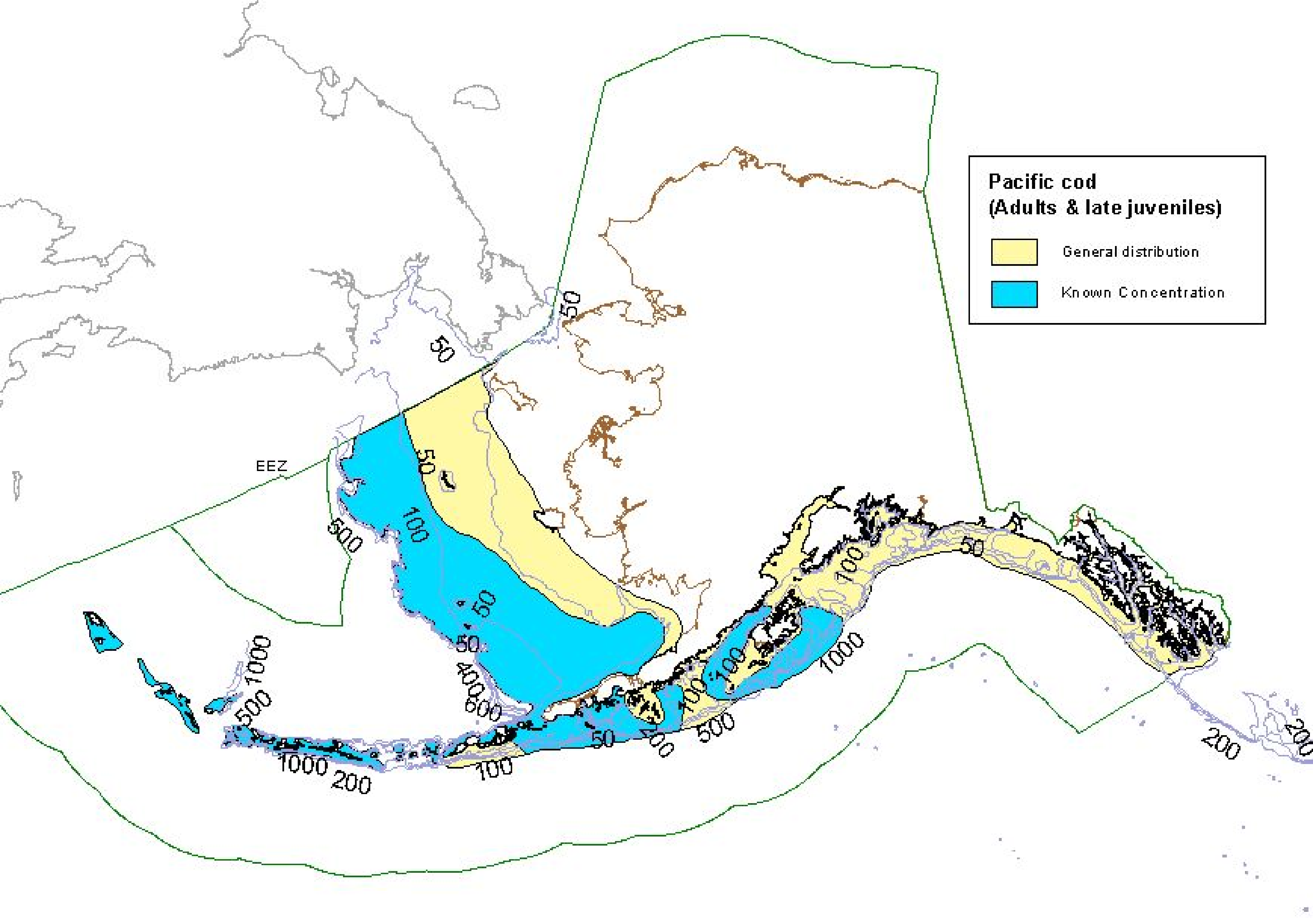
Sablefish
(Adults & late juveniles)
General distribution
Known Concentration
EEZ
50
100
200
400
500
600
1000

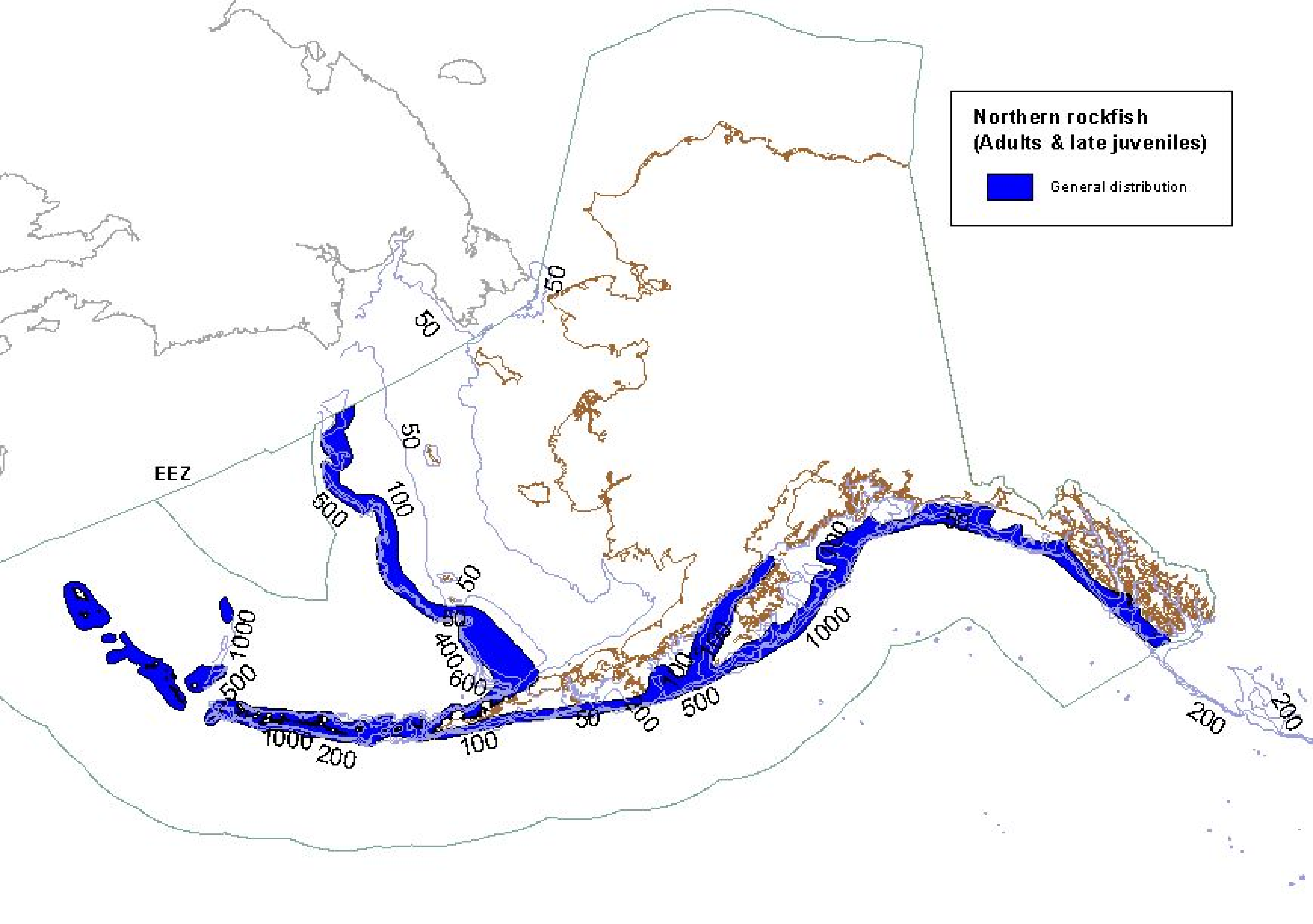


Rock sole
(Adults & late juveniles)
General distribution
Known concentration
EEZ
50
100
200
400
500
600
1000

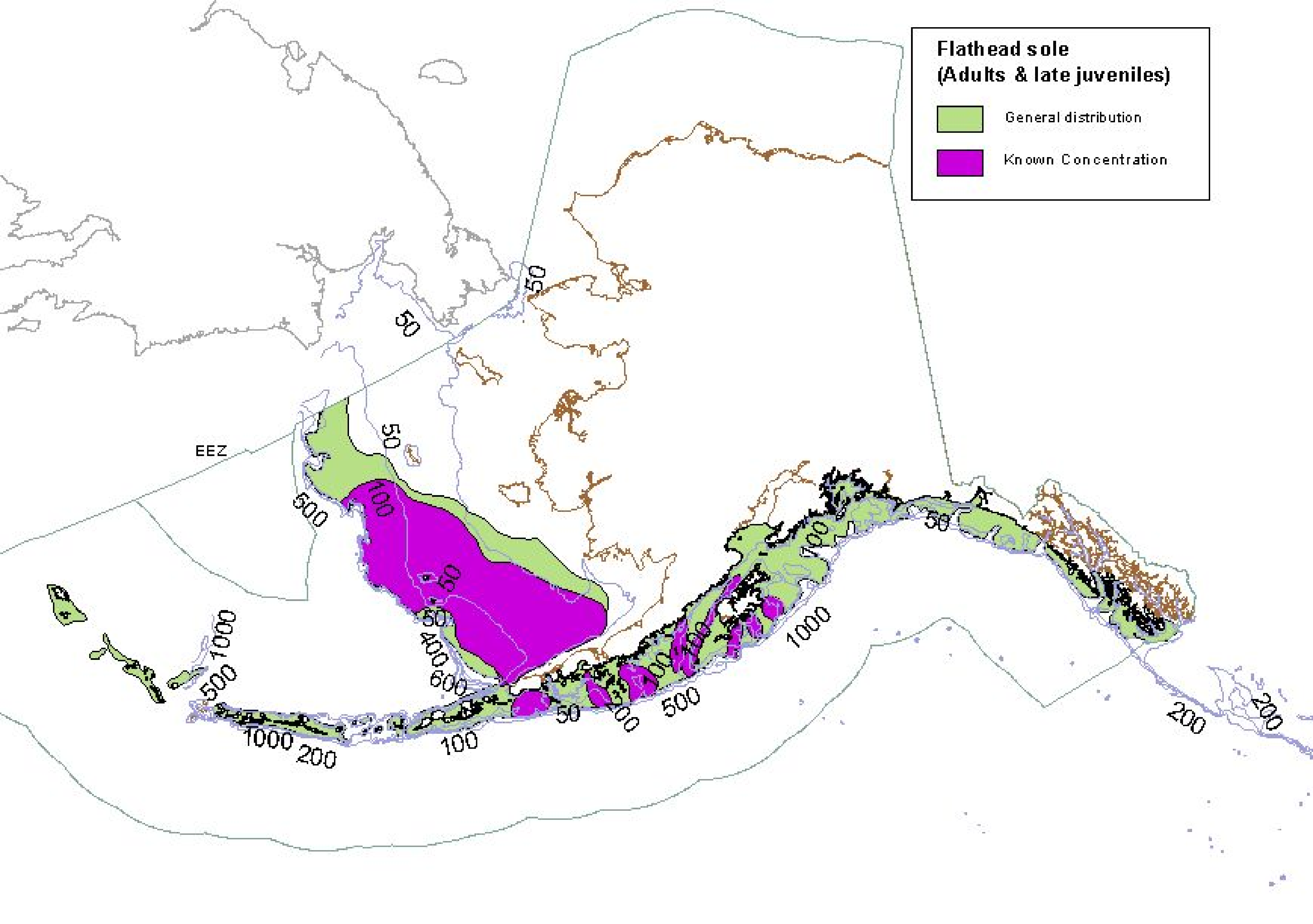

Rex sole
(Adults & late juveniles)
General distribution
EEZ
50
50
50
100
500
50
50
400
600
1000
500
1000
200
100
50
200
100
100
100
500
1000
50
200


Pacific Ocean Perch
(Adults & late juveniles)
General distribution
50
50
50
100
500
50
50
400
600
1000
500
1000
200
100
50
200
500
100
100
100
1000
50
200

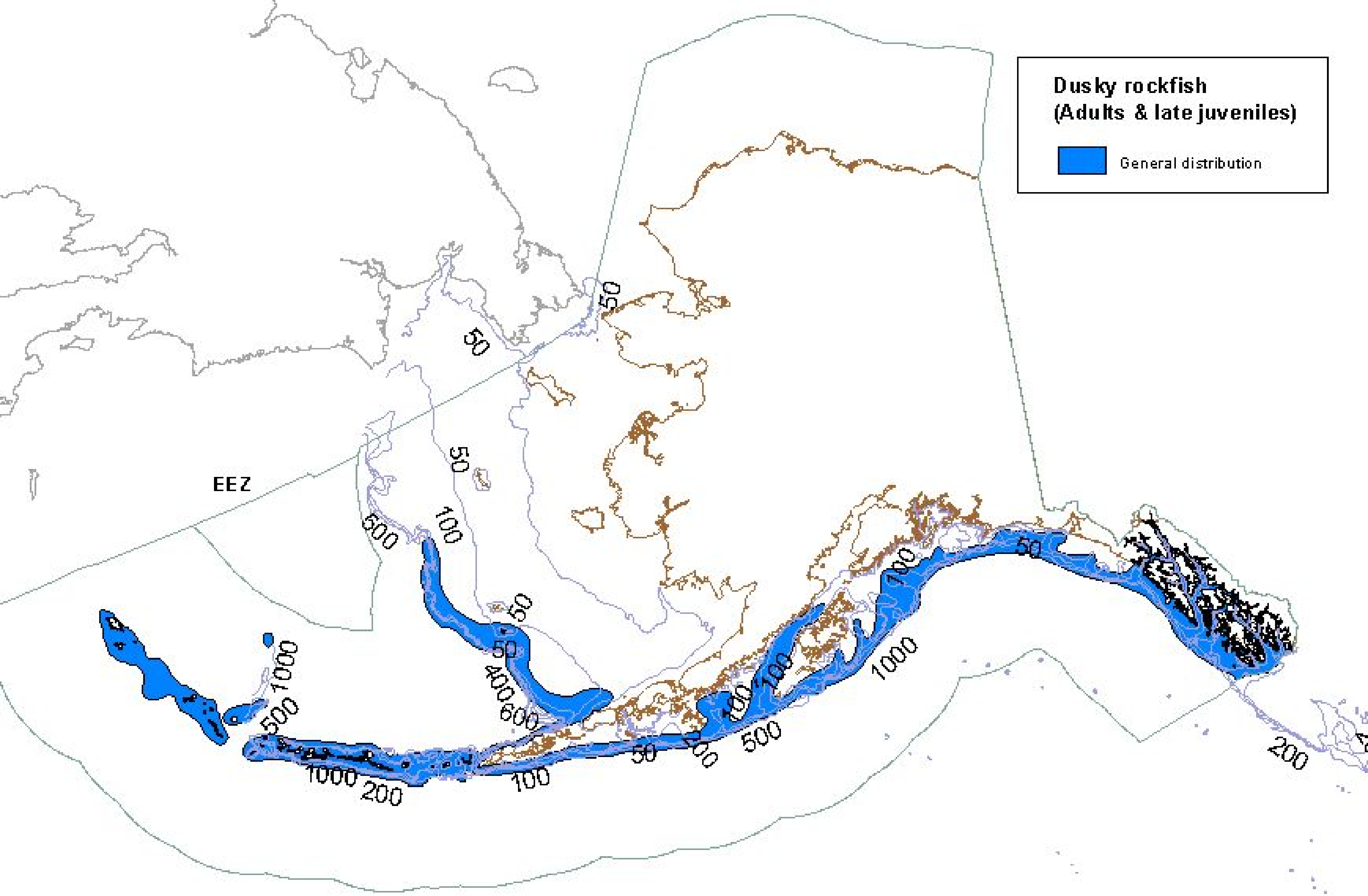

Pacific cod
(Adults & late juveniles)
General distribution
Known Concentration
EEZ
50
100
200
400
500
600
1000



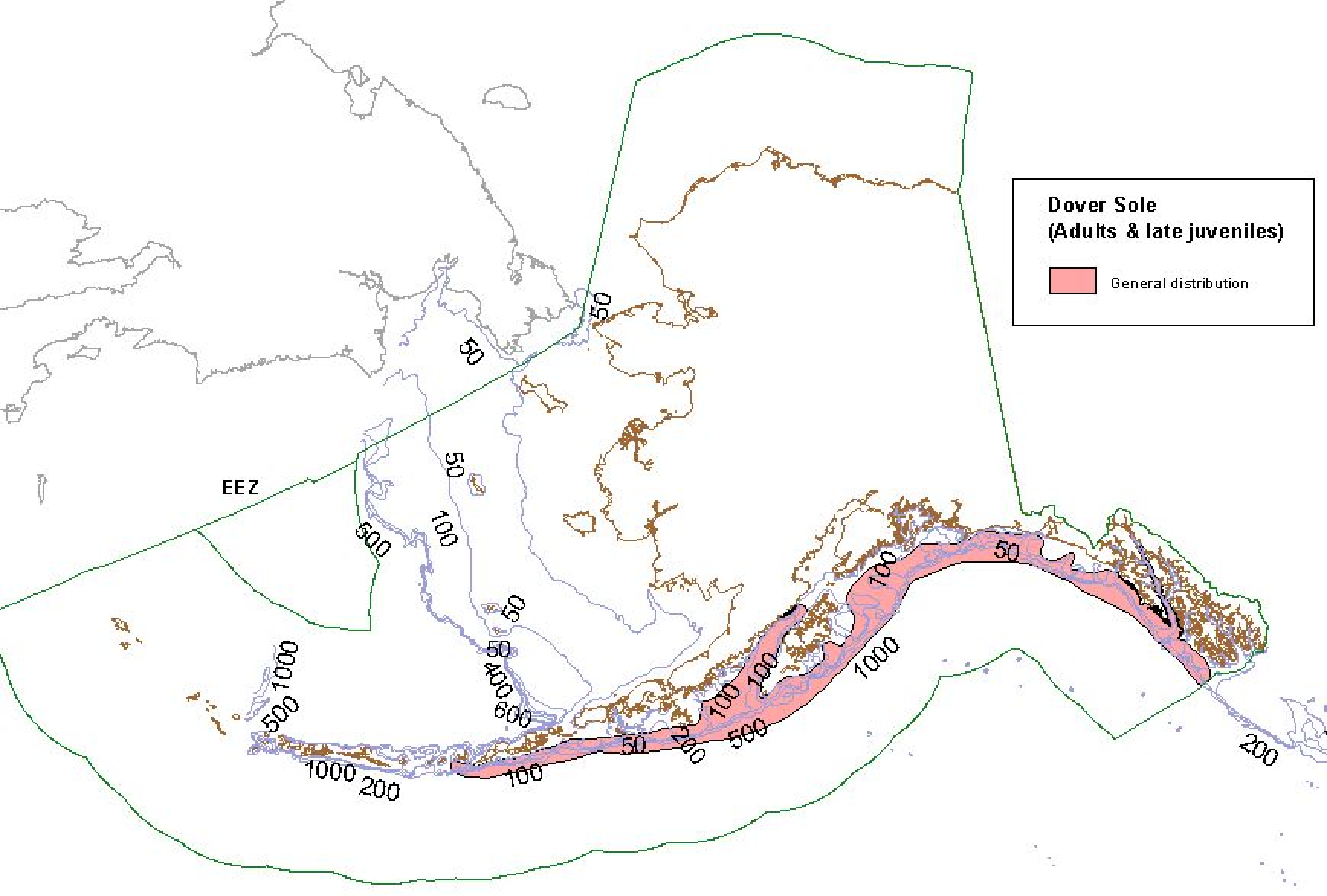
Northern rockfish
(Adults & late juveniles)
General distribution
EEZ
50
50
50
50
50
100
500
400
600
1000
500
1000
200
100
50
200
500
1000
200
200

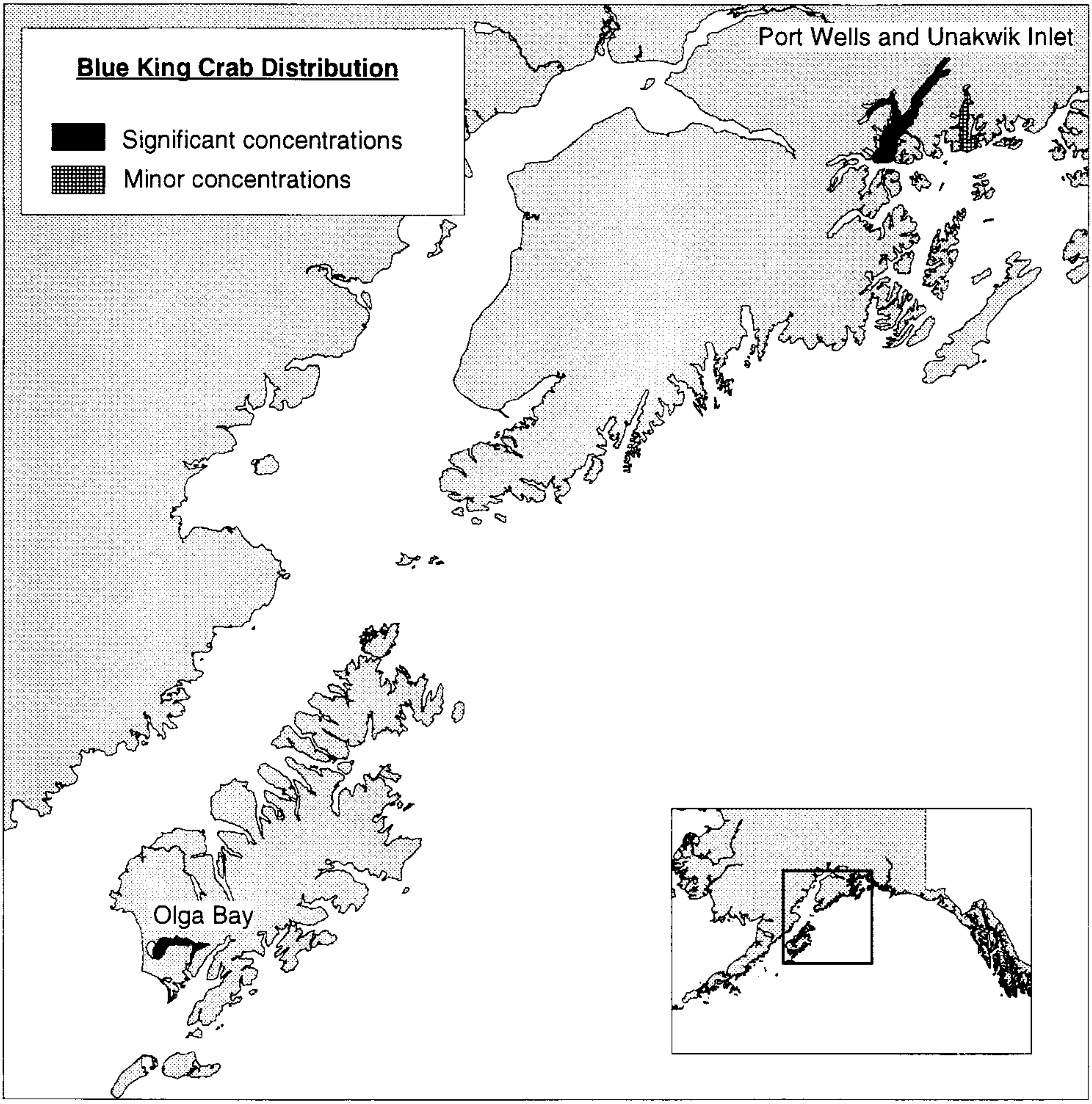


Flathead sole
(Adults & late juveniles)
General distribution
Known Concentration
EEZ
50
100
200
400
500
600
1000

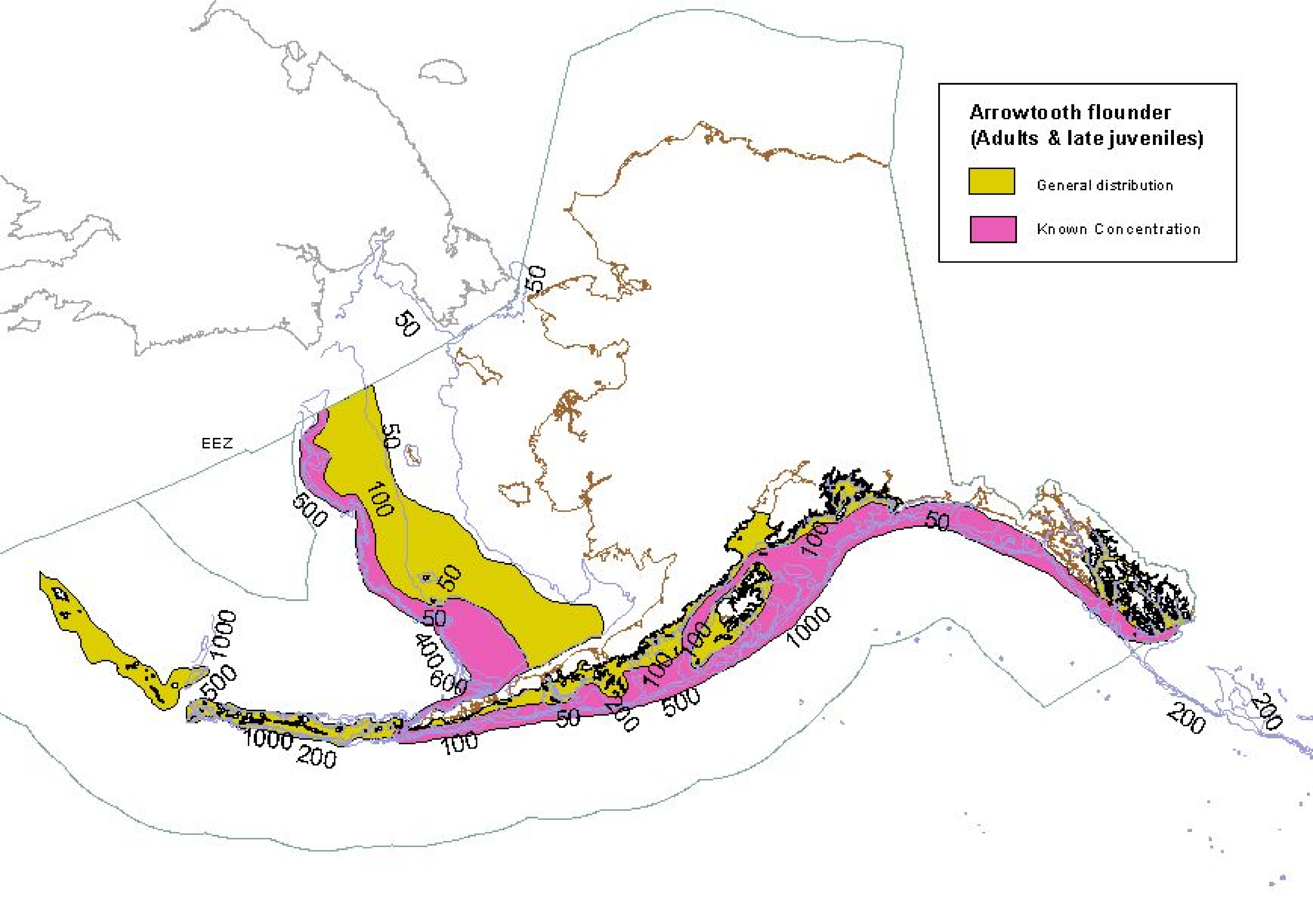


Dusky rockfish
(Adults & late juveniles)
General distribution
EEZ

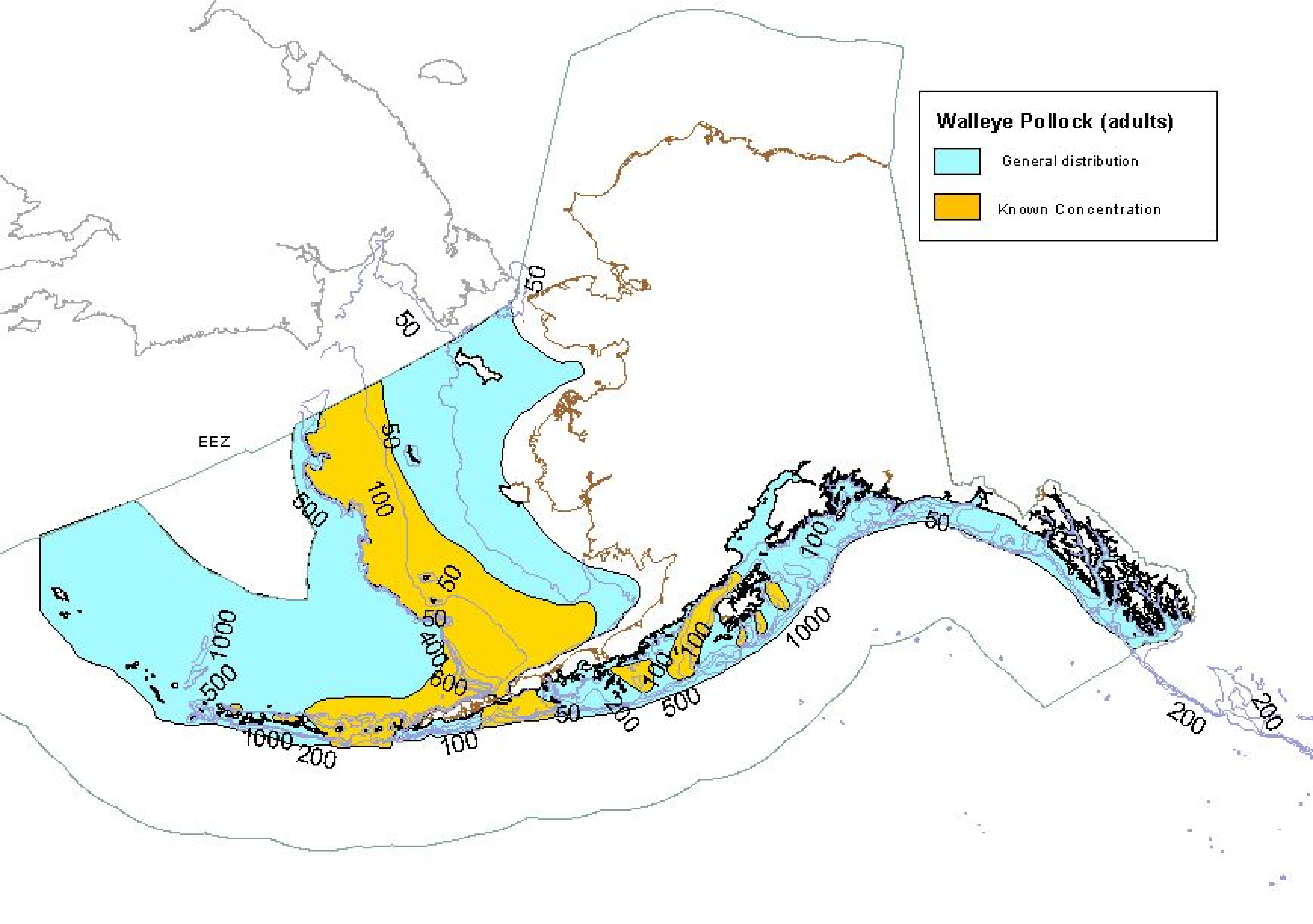

Dover Sole
(Adults & late juveniles)
General distribution
EEZ
50
50
50
50
50
50
50
100
100
100
100
100
200
200
200
400
500
500
500
600
1000
1000
1000



Source: ADF&G Fishticket database, Dave Jackson and Charles Trowbridge, pers. comm.



Arrowtooth flounder
(Adults & late juveniles)
General distribution
Known Concentration
EEZ
50
100
200
400
500
600
1000



Walleye Pollock (adults)
General distribution
Known Concentration
EEZ
50
50
50
100
500
50
50
400
600
1000
500
1000
200
100
50
200
500
100
100
1000
50
100
200
200

6.3 BSAI King and Tanner Crab

Stocks of BSAI crabs have widely varying levels of information available. Some stocks have only limited fishery data while Bristol Bay red king and Tanner crabs have been studied intensely. In reviewing the array of information, the technical team defined five life history stages for crab based on their habitat requirements and five information levels to describe and identify EHF. The team noted that the type and level of information available for most BSAI crabs' life stage was minimal compared to the expectations of the national guidelines for description and identification of EFH.

Life Stages

Life history stages of king and Tanner crabs were defined according to accepted habitat usage: eggs, larvae, early juveniles, late juveniles, and mature crabs (Tyler and Kruse 1996, 1997; Epifanio 1988).

Egg Stage

Female king and Tanner crab extrude eggs, carry and nurture them outside the maternal body. The number of eggs developed by the female increases with body size and is linked to nutrition at favorable temperatures. Information on egg bearing females is used to define habitat for the egg stage of crabs.

Larval Stage

Successful hatch of king and Tanner crab larvae is a function of temperature and concentration of diatoms so presence of larvae in the water column can vary accordingly. Larvae are planktonic. They are minute forms and their sustained horizontal swimming is inconsequential compared to horizontal advection by oceanographic conditions. Larvae vertically migrate within the water column to feed. Diel vertical migration may be a retention mechanism to transport larvae inshore.

Early Juvenile Stage

The early juvenile stage includes crabs first settling on the bottom (glacothoe and megalops), young of the year crabs, and crabs up to a size approximating age 2. Habitat relief is obligatory for red and blue King crabs of this life stage. Individuals are typically less than 20mm CL distributed in nearshore waters among niches provided by sea star arms, anemones, shell hash, rocks and other bottom relief. Early juvenile Tanner crab settle on mud, are known to occur there during summer but are not easily found in this habitat in winter.

Late Juvenile Stage

The late juvenile stage for crab is defined as the size at about age 2 to the first size of functional maturity. Late juvenile crabs are typically found further offshore in cooler water than early juvenile crabs. Smaller red king crabs of this life stage form pods during day that break apart during the night when the crabs forage and molt. As these crabs increase in size, podding behavior declines and the animals are found to forage throughout the day.

Mature Stage

Mature crabs are defined as those crabs of a size that is functionally mature. Functional maturity is based on size observed in mating pairs of crabs. This maturity definition differs from morphometric maturity based on chela height and physiological maturity when sperm or eggs can be produced. The mature stage includes crabs from the first size of functional maturity to senescence.

Information Levels

The type of habitat information available for almost all crab species is spatial distribution over depth and broad geographic areas as collected from survey and fishery samples that have limited linkage with habitat characteristics. Coupled with traditional knowledge these data demonstrate that geographic distribution of crab contracts and expands due to a variety of factors including, but not limited to, temperature changes, current patterns, changes in population size, and changes in predator and prey distributions. The distributions of many crab species' life stages are based on historical data and information about the entire geographic range is included in the text description of each species. The technical team agreed that maps should delineate where possible the EFH distributions and known areas of high crab concentrations within United States (3-200 nautical miles) and State of Alaska (0-3 miles) waters.

Specific data are lacking to precisely define localized habitat for each life stage of crab because surveys are cost prohibitive to document the expanse of king and Tanner crab habitat along the coast line of the Bering Sea and Aleutian Islands and on the continental shelf and slope. Consequently, the oceanographic (temperature, salinity, nutrient, current), trophic (presence/absence of food and predators), and physical (depth, substrate, latitude, and longitude) characteristics of crab habitat are restricted for most crab species and life stages to broad general associations. Types of data used to describe habitat association of BSAI king and Tanner crabs include: AFSC trawl surveys; the OCSEAP survey, NMFS and ADF&G tagging surveys, ADF&G surveys; ADF&G shellfish observer program; and ADF&G harvest records.

A primary source of many of the maps featured in this document was the NOS publication, Coastal and Ocean Zones Strategic Assessment: Data Atlases of the West Coast of North America and the Bering, Chukchi and Beaufort Seas. These maps provide the reasonable coverage of the distributions of larger crabs. However, the source data depends on the catchability of female crabs and late juvenile crabs in survey gear. Only irregular surveys target larval and early juvenile life stages. Additionally, inaccuracies might exist in extending mapped distributions based on habitat associations. The distributions shown in this preliminary report are first-cut and should be verified and updated as better or more current data become available. Information levels used in description of EFH for crab species were based on the best scientific data available. The Crab Technical Team adopted a classification scheme that includes an additional level of information, level 0. Level 0 is considered a subset of the information level 1 definition in the proposed guidelines. The Crab Technical Team noted that for BSAI crabs, the minimum level of habitat information has been gathered by systematic sampling therefore opportunistic samples of crab have not been included in the assessment of crab EFH. Level 0 denotes absence of systematic sampling data for a species and life stage. Level 1 information is presence/absence of systematic sampling data for a species and life stage and encompasses the area of general distribution for some or all portions of its' geographic range. Level 2 information is density of a crab species' life stage by depth, geographic area and inferred habitat. Information level 2 includes the definition for level 1 and additional data that refines definition of habitat occupied by a species' life stage.

Table 6.6 Levels of essential fish habitat information currently available for BSAI king and Tanner crab, by life history stage. Juveniles were subdivided into early and late juvenile stages based on survey selectivity curves.

Species/Stock	Eggs	Larvae	Early Juveniles[1]	Late Juveniles[2]	Adults
Red King Crab					
Bristol Bay	2	2	1	2	2
Pribilof Islands	2	1	0c	2	2
Norton Sound	2	0c	0c	2	2
Dutch Harbor	2	0c	0c	2	2
Adak	1	0c	0c	0c	1
Blue King Crab					
Pribilof Islands	2	1	2	2	2
St. Matthew I.	1	0c	0c	1	2
St. Lawrence I.	0b	0c	0c	0c	1
Golden King Crab					
Seaguam Pass	2	0c	0c	2	2
Adak	1	0c	0c	1	2
Pribilof Islands	1	0c	0c	1	2
Northern District	0c	0c	0c	0c	0c
Scarlet King Crab					
Bering Sea	0b	0c	0c	0c	1
Adak	0b	0c	0c	0c	1
Dutch Harbor	0b	0c	0c	0c	1
Tanner Crab (C. bairdi)					
Bristol Bay	2	1	1	2	2
Pribilof Islands	2	1	1	2	2
Eastern Aleutians	1	0c	1	2	2
Western Aleutians	0b	0c	0c	0c	1
Snow Crab (C. Opilio)					
Eastern Bering Sea	2	1	1	2	2
Grooved Crab (C. tanneri)					
Bering Sea	0b	0c	0c	0c	1
Eastern Aleutians	0b	0c	0c	0c	1
Western Aleutians	0b	0c	0c	0c	1
Triangle Crab (C. angulatus)					
Bristol Bay	1	0c	0c	0c	1
Eastern Aleutians	1	0c	0c	0c	1

[1] Early juvenile crab are defined as settled crab up to a size approximating age 2.
[2] Late juvenile crab are defined as age 2 through the first size of functional maturity.
Note: For any crab species/stock's life stage at level 0, information was insufficient to infer general distribution (0a).
0b: No information on the life stage, but some information on a similar species or adjacent life stage from which to infer general distribution.
0c: No information on the actual species' life stage and no information on a similar species or adjacent life stages, or where complexity of a species stock structure prohibited inference of general distribution.

Recommendation

The Crab Technical Team based description and identification of essential habitat on the level of information available. In cases where a level 0 has been assigned, no data exist and no comment on EFH has been offered. The Crab Technical Team recommends that EFH be defined as everywhere the species' life stage has been documented through systematic sampling, plus all areas of similar habitat based on NOS charts, the literature, and the opinions of scientists and persons with local knowledge. This EFH recommendation would apply to a species' life stage with level 1 and greater information.

The Crab Technical Team did note distinguishing characteristics of crab habitat "necessary for spawning, breeding, feeding and growth to maturity" based on the best available scientific data and collective scientific opinion. Habitat can be partitioned according to depth both between crab species and among different life history stages of a given species.

Shallow inshore areas (less than 50 m depth) are very important to king crab reproduction as they move onshore to molt and mate. Tanner crabs also occupy shallower depths during molting and mating. All BSAI crab are highly vulnerable to predation and damage during molting when they shed their exoskeleton. King crab usually molt annually to mate while Tanner and snow crab exhibit terminal molt and carry sperm for future clutch fertilization. The habitat occupied by molting and mating crab differs from that occupied by mature crabs during the remainder of the year. The Crab Technical Team noted protection of crab in molting mating habitat during this sensitive life history stage is important.

Larval stages are distributed according to vertical swimming abilities, and the currents, mixing, or stratification of the water column. Generally, the larval stages occupy the upper 30 m, often in the mixed layer near the sea surface. As the larvae molt and grow into more actively swimming stages they are able to seek a preferred depth. After molting through multiple larval stages, crabs settle on the bottom. Settlement on habitat with adequate shelter, food, and temperature is imperative to survival of first settling crabs. Young of the year red and blue king crabs require nearshore shallow habitat with significant cover that offers protection (e.g. sea stars, anemones, macroalgae, shell hash, cobble, shale) to this frequently molting life stage. Early juvenile stage Tanner and snow crab also occupy shallow waters and are found on mud habitat. Late Juvenile stage crabs are most active at night when they feed and molt. The Crab Technical Team emphasized the importance of shallow areas to all early juvenile stage crabs and in particular the importance to red and blue king crabs of high relief habitat nearshore with extensive biogenic assemblages. The area north and adjacent to the Alaska peninsula (Unimak Island to Port Moller), the eastern portion Bristol Bay, and nearshore areas of the Pribilof and Saint Matthew Islands are locations known to be particularly important for king crab spawning and juvenile rearing.

Each life stage for stocks of BSAI crabs is concentrated at some combination of depth, habitat, geographic area, or time of year. Areas of known concentration of some species' life stages can be identified within the reported general distribution of several BSAI crab stocks. However, information to delineate areas of known concentration for each life stage is not available for many of the BSAI crabs.

The Crab Technical Team recommends that EFH be designated as the general distribution of a species' life stage. The reasons for selecting the general distribution even when known concentrations can be delineated include: 1) temporal variation in location of crab life stages within habitat; 2) resolution of habitat descriptions differs from known distributions of a crab species' life stage relative to habitat; 3) concentrations of mature crabs contracts and expands with decline and rise of population abundance likely changing the boundaries of known concentration; and 4) geographic areas with high concentration of a species' life stage are encompassed in the general distribution.

All crab species' life stages in the BSAI rely on habitat associated prey. From settling larvae to senescence, crabs dwell on the bottom and are dependent on benthic feeding. The importance of habitat quality to crab diet seems intuitive but is not quantified for benthic life stages. The team recognized change in diet due to habitat disturbance and alteration will impact crab survival and potentially long-term production.

(See table of contents for the following tables)
-Life History Traits for BSAI King and Tanner Crab Species
-Habitat Associations for BSAI King and Tanner Crab Species

EFH Definition for Red king crab

Egg - Level 1 & 2
See mature. Egg hatch of larvae is synchronized with the spring phytoplankton bloom in Southeast Alaska suggesting temporal sensitivity in the transition from benthic to planktonic habitat. Essential habitat of the red king crab egg stage is based on the general distribution (level 1) and habitat related density (level 2) of egg bearing red king crabs of the Bristol Bay, Pribilof Islands, Norton Sound and Dutch Harbor stocks. General distribution (level 1) of egg bearing female red king crab is used to identify essential habitat for the Adak stock.

Larvae - Level 0_c, Level 1 and Level 2
No EFH definition determined for the Norton Sound, Dutch Harbor and Adak stocks.
Red king crab larvae spend 2 - 3 months in pelagic larval stages before settling to the benthic life stage. Reverse diel migration and feeding patterns of larvae coincide with the distribution of food sources. Essential habitat is identified for larvae of the Bristol Bay red king crab stock using the general distribution (level 1) and density (level 2) of larvae in the water column. Essential habitat is defined for larvae of the Pribilof Islands stock based on knowledge of the general distribution (level 1) of larvae in the water column. No essential habitat is defined for larvae of red king crab stocks in Norton Sound, Dutch Harbor and Adak waters.

Early Juvenile - Level 0_c and Level 1
No EFH definition determined for the Northern District stock.
Early juvenile stage red king crabs are solitary and need high relief habitat or coarse substrate such as boulders, cobble, shell hash, and living substrates such as bryozoans and stalked ascidians. Young-of-the-year crabs occur at depths of 50 m or less. Essential habitat for early juveniles is defined for Bristol Bay red king crabs as the general distribution (level 1). No essential fish habitat is defined for red king crab early juveniles in Pribilof Islands, Norton Sound, Dutch Harbor and Adak stocks.

Late Juvenile - Level 0_c and Level 2
No EFH definition determined for the Adak stock.
Late juvenile stage red king crabs of the ages of two and four years exhibit decreasing reliance on habitat and a tendency for the crab to form pods consisting of thousands of crabs. Podding generally continues until four years of age (about 6.5 cm), when the crab move to deeper water and join adults in the spring

migration to shallow water for molting and mating. Essential habitat based on general distribution (level 1) and density (level 2) of late juvenile red king crabs is known for Bristol Bay, Pribilof Islands, Norton Sound and Dutch Harbor stocks. Essential habitat is not defined for late juvenile red king crabs in the Adak stock.

Mature -Level 1 and 2
Mature red king crabs exhibit seasonal migration to shallow waters for reproduction. The remainder of the year red king crabs are found in deep waters. In Bristol Bay, red king crabs mate when they enter shallower waters (<50 m), generally beginning in January and continuing through June. Males grasp females just prior to female molting, after which the eggs (43,000 to 500,000 eggs) are fertilized and extruded on the female's abdomen. The female red king crab carries the eggs for 11 months before they hatch, generally in April. Essential habitat for mature red king crabs is known for Bristol Bay, Pribilof Islands, Norton Sound and Dutch Harbor stocks based on general distribution (level 1) and density (level 2). Essential habitat for mature red king crabs in Adak is known from general distribution data (level 1).

<u>EFH Definition for Blue King Crab</u>

Egg - Level 0_b, Level 1 and Level 2
See Mature. Essential habitat for eggs is known for the stock of blue king crab in the Pribilof Islands based on general distribution (level 1) and density (level 2) of egg bearing female crabs. Essential habitat for eggs of the St. Matthew Island blue king crab stock is based on general distribution (level 1) of the egg bearing females. Essential habitat for eggs of the St. Lawrence Island blue king crab stock is inferred from incidental catch of mature female crab.

Larvae - Level 0_c and Level 1
No EFH definition determined for the St. Matthew Island and St. Lawrence stocks.
Blue king crab larvae spend 3.5 to 4 months in pelagic larval stages before settling to the benthic life stage. Larvae are found in waters of depths between 40 to 60 m. Essential habitat of larval blue king crab of the Pribilof Islands stock is defined using the general distribution (level 1) of larvae in the water column. Information to define essential habitat is not available for the St. Matthew Island and St. Lawrence Island stocks of larval blue king crab.

Early Juvenile - Level 0_c and Level 2
No EFH definition determined for the St. Matthew and St. Lawrence Island stocks.
Early juvenile blue king crabs require refuge substrate characterized by gravel and cobble overlaid with shell hash, and sponge, hydroid and barnacle assemblages. These habitat areas have been found at 40-60 m around the Pribilof Islands. Essential habitat of early juvenile blue king crabs is based on general distribution (level 1) and density (level 2) of this life stage in the Pribilof Island stock. Information to define essential habitat for early juvenile blue king crabs in the St. Matthew Island and St. Lawrence Island stocks is not available.

Late Juvenile - Level 0_c, Level 1 and Level 2
NO EFH definition determined for the St. Lawrence Island stock.
Late juvenile blue king crab require nearshore rocky habitat with shell hash. Essential habitat is based on general distribution (level 1) and density (level 2) of late juvenile blue king crab of the Priblilof Islands stock. General distribution (level 1) of the late juvenile blue king crabs is used to identify essential habitat for the St. Matthew Island stock. Information is not available to define essential habitat for the St. Lawrence Island stock of late juvenile blue king crab.

Mature - Level 1 and Level 2
Mature blue king crabs occur most often between 45-75 m depth on mud-sand substrate adjacent to gravel rocky bottom. Female crabs are found in a habitat with a high percentage of shell hash. Mating occurs in mid-spring. Larger older females reproduce biennially while small females tend to reproduce annually. Fecundity of females range from 50,000-200,000 eggs per female. It has been suggested that spawning may depend on availability of nearshore rocky-cobble substrate for protection of females. Larger older crabs disperse farther offshore and are thought to migrate inshore for molting and mating. General distribution (level 1) and density (level 2) of mature blue king crab are used to identify essential habitat for the Pribilof Islands and St. Matthew Island stocks. Essential habitat of mature blue king crab is based on distribution (level 1) data for the St. Lawrence Island stock.

EFH Definition for Golden King Crab

Egg - Level 0_c, Level 1 and Level 2
No EFH definition determined for the Northern District stock.
See mature. General distribution (level 1) and density (level 2) of egg bearing female golden king crabs is used to identify essential habitat for the Sequam Pass stock. Essential habitat for the egg life stage of the Adak and Priblilof Islands stocks is based on general distribution (level 1) of the egg bearing female crabs.

Larvae - Level 0_c - No EFH definition determined
Information to define essential habitat of golden king crab larvae is not available for the Seguam Pass, Adak, Pribilof Islands or Northern District stocks.

Early Juvenile - Level 0_c - No EFH definition determined
Information to define essential habitat of early juvenile golden king crabs is not available for the Seguam Pass, Adak, Pribilof Islands or Northern District stocks.

Late Juvenile - Level 0_c, Level 1 and Level 2
No EFH definition determined for the Northern District stock.
Late juvenile golden king crabs are found throughout the depth range of the species. Abundance of late juvenile crab increases with depth and these crab are most abundant at depths >548 m. Essential habitat for late juvenile golden king crabs is based on general distribution (level 1) and density (level 2) of this life stage for the Sequam Pass stock. General distribution (level 1) of late juvenile golden king crabs is used to identify essential habitat for the Adak and Pribilof Islands stock. Information to define essential habitat is not available for late juvenile golden king crabs of the Northern District stock.

Mature - Level 0_c, and Level 2
No EFH definition determined for the Northern District stock.
Mature golden king crabs occur at all depths within their distribution. Males tend to congregate in somewhat shallower waters than females, and this segregation appears to be maintained throughout the year. Legal male crabs are most abundant between 274 m and 639 m. Abundance of sub-legal males increases at depth >364 m. Female abundance is greatest at intermediate depths between 274 m and 364 m. General distribution (level 1) and density (level 2) of mature golden king crabs are used to identify essential habitat for the Sequam Pass, Adak and Pribilof Islands stocks. Information is not available to define essential habitat for mature golden king crabs of the Northern district stock.

<u>EFH Definition for Scarlet King Crab</u>

Egg - Level 0_b
See Mature. Information for scarlet king crab eggs is not available for the Bering Sea, Adak or Dutch Harbor stocks. General distribution of the egg life stage, is inferred from incidental catch of mature females.

Larvae - Level 0_c - No EFH definition determined
Information to define essential habitat for scarlet king crab larvae is not available for the Bering Sea, Adak or Dutch Harbor stocks.

Early Juvenile - Level 0_c - No EFH definition determined
Information to define essential habitat for early juvenile scarlet king crabs is not available for the Bering Sea, Adak or Dutch Harbor stocks.

Late Juvenile - Level 0_c - No EFH definition determined
Information to define essential habitat for late juvenile scarlet king crabs is not available for the Bering Sea, Adak or Dutch Harbor stocks.

Mature - Level 1
Essential habitat for mature scarlet king crabs is based on the general distribution (level 1) of mature golden king crabs. Mature scarlet king crabs are caught incidentally in the golden king crab and *C. tanneri* fisheries.

<u>EFH Definition for Tanner Crab (*C. bairdi*)</u>

Egg - Level 0_b, Level 1 and Level 2
See mature. Essential habitat for eggs is known for the stocks of *C. bairdi* Tanner crabs in Bristol Bay and the Pribilof Islands based on general distribution (level 1) and density (level 2) of egg bearing female crabs. Essential habitat for eggs of the Eastern Aleutian *C. bairdi* Tanner crab stock is based on general distribution (level 1) of the egg bearing females. Essential habitat for eggs of the Western Aleutian *C. bairdi* Tanner crab stock is inferred from the general distribution of mature females.

Larvae - Level 0_c and Level 1
No EFH definition determined for the Eastern Aleutian and Western Aleutian stocks.
Larvae of *C. bairdi* Tanner crabs are typically found in Bering Sea Aleutian Island water column from 0 – 100 m in early summer. They are strong swimmers and perform diel migrations in the water column (down at night). They usually stay near the depth of the chlorophyll maximum during the day. The last larval stage settles onto the bottom mud. Essential habitat of *C. bairdi* Tanner crab larvae is based on general distribution (level 1) for the Bristol Bay and Pribilof Islands stocks. Information is not available to define essential habitat for larval *C. bairdi* Tanner crab in the Eastern Aleutian and Western Aleutian stocks.

Early Juvenile - Level 0_c and Level 1
No EFH definition determined for the Western Aleutian stock.
Early juvenile *C. bairdi* Tanner crabs occur at depths of 10 - 20 m in mud habitat in summer and are known to burrow or associate with many types of cover. Early juvenile *C. bairdi* Tanner crabs are not easily found in winter. Essential habitat of early juvenile *C. bairdi* Tanner crabs is identified by the general distribution (level 1) of this life stage for the Bristol Bay, Pribilof Islands, and Eastern Aleutian

stocks. Information to identify essential habitat of early juvenile *C. bairdi* Tanner crabs in not available for the Western Aleutian stock.

Late Juvenile - Level 0_c and Level 1
No EFH definition determined for the Western Aleutian stock.
The preferred habitat for late juvenile *C. bairdi* Tanner crabs is mud. Late juvenile Tanner crab migrate offshore of their early juvenile nursery habitat. Essential habitat of late juvenile *C. bairdi* Tanner crabs is based on the general distribution (level 1) and density (level 2) of this life stage for the Bristol Bay, Pribilof Islands, and Eastern Aleutian stocks. Information to identify essential habitat of late juvenile *C. bairdi* Tanner crabs in not available for the Western Aleutian stock.

Mature - Level 1 and Level 2
Mature *C. bairdi* Tanner crabs migrate inshore and mating is known to occur February through June. Mature female *C. bairdi* Tanner crabs have been observed in high density mating aggregations, or pods, consisting of hundreds of crabs per mound. These mounds may provide protection from predators and also attract males for mating. Mating need not occur every year, as female *C. bairdi* Tanner crabs can retain viable sperm in spermathecae up to 2 years or more. Females carry clutches of 50,000 to 400,000 eggs and nurture the embryos for one year after fertilization. Primiparous females may carry the fertilized eggs for as long as 1.5 years. Brooding occurs in 100-150 m depths. Essential habitat is based on the general distribution (level 1) and density (level 2) of mature *C. bairdi* Tanner crabs of the Bristol Bay, Pribilof Islands, and Eastern Aleutian stocks. Essential habitat of mature *C. bairdi* Tanner crabs is identified as the general distribution (level 1) for the Western Aleutian stock.

<u>EFH Definition for Snow Crab (*C. opilio*)</u>

Egg - Level 2
See Mature. Essential habitat for eggs is known for the stocks of *C. opilio* snow crabs in the Eastern Bering Sea based on general distribution (level 1) and density (level 2) of egg bearing female crabs.

Larvae - Level 1
Larvae of *C. opilio* snow crab are found in early summer and exhibit diel migration. The last of 3 larval stages settles onto bottom in nursery areas. Essential habitat is based on general distribution (level 1) of *C. opilio* snow crab larvae of the Eastern Bering Sea stock.

Early Juvenile - Level 1
Shallow water areas of the Eastern Bering Sea are considered nursery areas for *C. opilio* snow crabs and are confined to the mid-shelf area due to the thermal limits of early and late juvenile life stages. Essential habitat is identified as the general distribution (level 1) of early juvenile crabs of the Eastern Bering Sea stock of *C. opilio* snow crabs.

Late Juvenile - Level 2
A geographic cline in size of *C. opilio* snow crabs indicates a large number of morphometrically immature crabs occur in shallow waters less than 80 m. Essential habitat is based on the general distribution (level 1) and density (level 2) of juvenile crabs of the Eastern Bering Sea stock of *C. opilio* snow crabs.

Mature - Level 2
Female *C. opilio* snow crabs are acknowledged to attain terminal molt status at maturity. Primiparous female snow crabs mate January through June and may exhibit longer egg development period and lower fecundity than multiperous female crabs. Multiparous female snow crabs are able to store spermatophores in seminal vesicles and fertilize subsequent egg clutches without mating. At least two clutches can be fertilized from stored spermatophores, but the frequency of this occurring in nature is not known. Females carry clutches of approximately 36,000 eggs and nurture the embryos for approximately one year after fertilization. However, fecundity may decrease up to 50% between the time of egg extrusion and hatching presumably due to predation, parasitism, abrasion or decay of unfertilized eggs. Brooding probably occurs in depths greater than 50 m. Changes in proportion of morphometrically mature crabs by carapace width have been related to an interaction between cohort size and depth.

EFH Definition for Grooved Tanner Crab (*C. tanneri*)

Egg - Level 0_b
See Mature. Information for grooved Tanner crab eggs is not available for the Bering Sea, Eastern Aleutian or Western Aleutian stocks. General distribution of the egg life stage is inferred from the distribution of mature females.

Larvae - Level 0_c - No EFH definition determined
Information to define essential habitat for larvae of grooved Tanner crabs is not available for the Bering Sea, Eastern Aleutian or Western Aleutian stocks.

Early Juvenile - Level 0_c - No EFH definition determined
Information to define essential habitat for early juvenile grooved Tanner crabs is not available for the Bering Sea, Eastern Aleutian, or Western Aleutian stocks.

Late Juvenile - Level 0_c - No EFH definition determined
Information to define essential habitat for late juvenile grooved Tanner crabs is not available for the Bering Sea, Eastern Aleutian, or Western Aleutian stocks.

Mature - Level 1
In the Eastern Bering Sea mature male grooved Tanner crabs may be found somewhat more shallow than mature females but male and female crabs don’t show clear segregation by depth. General distribution (level 1) of mature grooved Tanner crabs is used to identify essential habitat of the Bering Sea, Eastern Aleutian, and Western Aleutian stocks.

EFH Definition for Triangle Tanner Crab (*C. angulatus*)

Egg - Level 1 - No EFH definition determined
See Mature. General distribution (level 1) of mature triangle Tanner crabs is used to identify essential habitat of the Bristol Bay and Eastern Aleutian stocks.

Larvae - Level 0_c - No EFH definition determined
Information to define essential habitat for larvae of triangle Tanner crabs is not available for the Bristol Bay or Eastern Aleutian stocks.

Early Juvenile - Level 0_c - No EFH definition determined
Information to define essential habitat for early juvenile triangle Tanner crabs is not available for the Bristol Bay or Eastern Aleutian stocks.

Late Juvenile - Level 0_c - No EFH definition determined
Information to define essential habitat for late juvenile triangle Tanner crabs is not available for the Bristol Bay or Eastern Aleutian stocks**.**

Mature - Level 1
The mean depth of mature male triangle Tanner crabs (647 m) is significantly less than for mature females (748 m) indicating some pattern of sexual segregation by depth. General distribution (level 1) of mature triangle Tanner crabs is used to identify essential habitat of the Bristol Bay and Eastern Aleutian stocks.

References

Armstrong, D.A., J.L. Armstrong, R. Palacios, G. Williams, G.C. Jensen, and W. Pearson 1985. Early life history of juvenile blue king crab, *Paralithodes platypus*, around the Pribilof Islands. *In:* Proceedings of the International King Crab Symposium UA Sea Grant report No. 85-12:211-230.

Blau, S. F., D. Pengilly, and D.A. Tracy. 1995. Distribution of Golden King crabs by sex, size and depth zones in the Eastern Aleutian Islands. *In*: International Symposium on Biology, Management, and Economics of Crabs from High Latitude Habitats. Lowell Wakefield Symposium, Univ. of Alaska Sea Grant College Program. AK-SG-96-02:167-186.

Blau. S. F. 1996. The 1995 St. Matthew Island blue king crab survey. Alaska Department of Fish and Game. Commercial Fisheries Management and Development Division. Regional Information Report No. 4K96-27. Kodiak. 36 p.

Blau. S. F., L. J. Watson, and J. Blackburn. 1996. The 1996 Norton Sound red king crab trawl survey. Alaska Department of Fish and Game. Commercial Fisheries Management and Development Division. Regional Information Report No. 4K96-54. Kodiak. 40 p.

Boyle, L., L. C. Byrne, and H. Moore. 1997. Alaska Department of Fish and Game Summary of the 1996 mandatory shellfish observer program database. Confidential. Alaska Department of Fish and Game. Commercial Fisheries Management and Development Division. Regional Information Report No. 4K97-51. Kodiak. 165 p.

Fritz, L. W., A. Greig, and R. Reuter. Catch-per-unit-effort, length, and depth distributions of major groundfish and bycatch species in the Bering Sea, Aleutian Islands and Gulf of Alaska regions based on research trawl survey data. U.S. Dep. Commerce, 148.153NOAA Tech. Memo. NMFS-AFSC. In press.

Incze, L. S., D. A. Armstrong, and S. L. Smith. 1987. Abundance of larval Tanner crabs (*Chionoecetes* spp.) in relation to adult females and regional oceanography of the southerastern Bering Sea. Can. J. Fish. Aquat. Sci. 44: 1143-1156.

Jewett, S.C. and H. M. Feder. 1981. Epifaunal invertebrates of the continental shelf of the eastern Bering and Chukchi Seas. Pages 1131-1153 *In* Hood, D.W. and J.A. Calder. The eastern Bering Sea shelf: oceanography and resources, Vol. II. University of Washington Press, Seattle, WA.

Mcbride, J., D. Fraser, and J. Reeves. 1982. Information on the distribution and biology of the golden (brown) king crab in the Bering Sea and Aleutian Islands Area. NWAFC Processed Report 82-02. 23 p.

McMurray, G., A.H. Vogel, P.A. Fishman, D.A. Armstrong, and S.C. Jewett. 1984. Distribution of larval and juvenile red king crabs (*Paralithodes camtschatica*) in Bristol Bay. Final Report, Outer Continental Shelf Environmental Assessment Program, Research Unit 639.

NOAA. 1987. Bering, Chukchi, and Beaufort Seas. Coastal and ocean zones, Strategic assessment: Data atlas. U.S. Dep. Commerc., NOAA, NOS.

NOAA. 1990. West coast of North America. Coastal and ocean zones, Strategic assessment: Data atlas. U.S. Dep. Commerc., NOAA, NOS.

NPFMC. *In preparation*. Preliminary essential fish habitat assessment report for the king and Tanner crabs of the Bering Sea and Aleutian Islands regions. North Pacific Fishery Management Council, 605 W. 4th Ave., Suite 306, Anchorage, AK 99501.

Otto, R.S. 1981. Eastern Bering Sea crab fisheries. In: Hood, D.W. and J.A. Calder. The eastern Bering Sea shelf: oceanography and resources, vol. 2:1037-66

Pereyra, W.T., J.E. Reeves, and R.G. Bakkala. 1976. Demersal fish and shellfish resources of the eastern Bering Sea in the Baseline Year 1975. NWAFC Processed Report.
Slizkin, A.G., and S.D. Bukin. 1989. Distribution, biology and abundance of blue crab, *Paralithodes platypus* in the Bering Sea. Pages 306-315 *In* Proceedings of the International Scientific Symposium on Bering Sea Fisheries. NOAA Tech. Memo NMFS F/NWC-163.
Somerton, D.A. and R.S. Otto 1986. Distribution and reproductive biology of the golden king crab, *Lithodes aequispina*, in the eastern Bering Sea. Fish. Bull 84(3):571-84.
U.S. Department of the Interior. 1986. Outer Continental Shelf Environmental Assessment Program, Final Report of Principle Investigators, Volume 53. Mineral Management Service, OCS Study, MMS 86-0115.

See table of contents for the following maps:

Red king crab eggs

Red king crab larvae

Red king crab juveniles

Red king crab late juveniles

Red king crab spawners

Red king crab matures

Blue king crab eggs

Blue king crab larvae

Blue king crab early juveniles

Blue king crab juveniles and matures

Golden king crab eggs

Golden king crab late juveniles and matures

Scarlet king crab eggs

Scarlet king crab matures

Tanner crab eggs

Tanner crab larvae

Tanner crab early juveniles

Tanner crab late juveniles and matures

Snow crab eggs

Snow crab larvae

Snow crab early juveniles

Snow crab late juveniles

Snow crab matures

Grooved Tanner crab eggs

Grooved Tanner crab matures

Triangle Tanner crab eggs

Triangle Tanner crab matures

Table 2

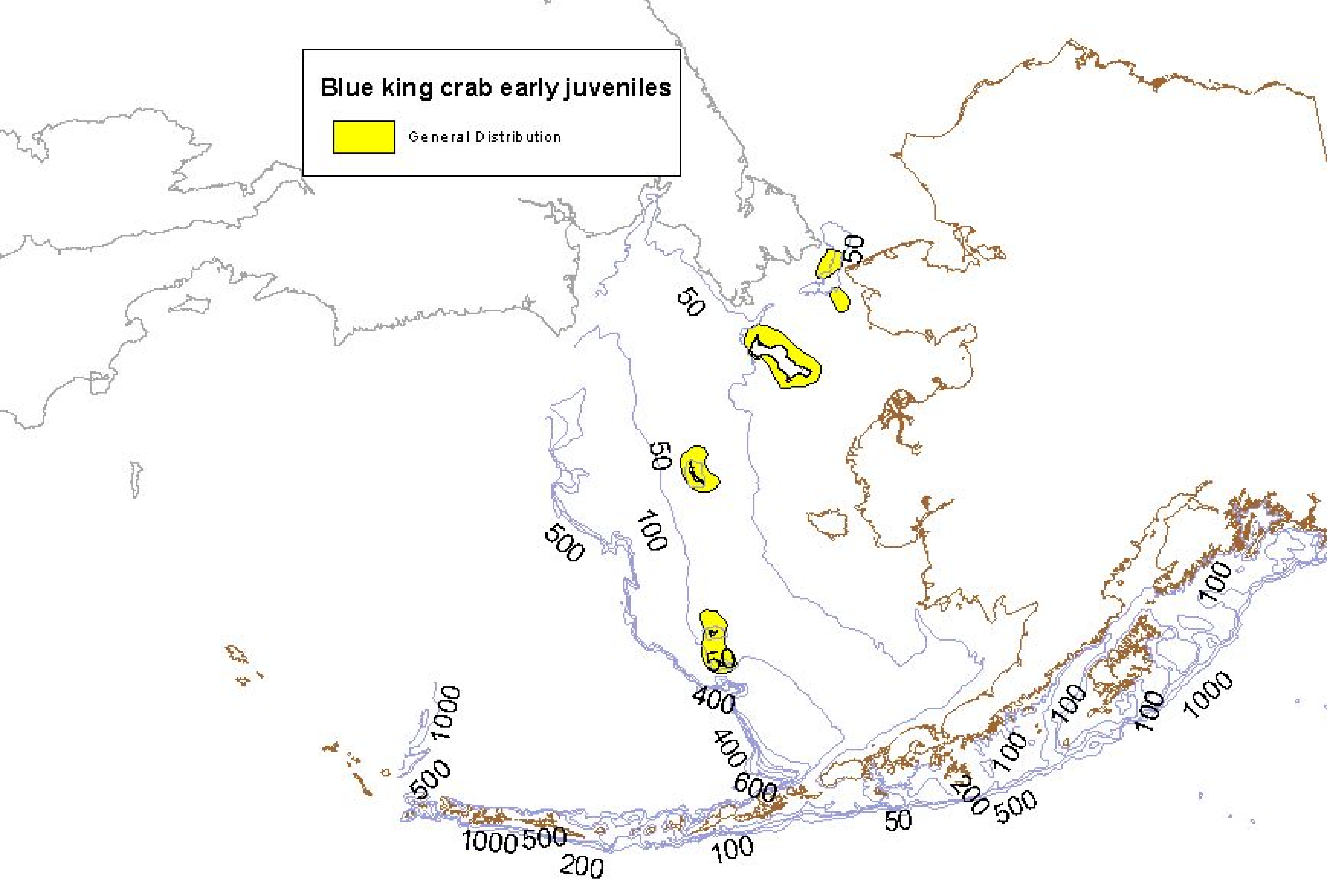
Life History Traits for BSAI King and Tanner Crab Species

			Feeding Types					Movements							Behavior								Periods				
Species	Life Stage\Activity	Duration of Life Stage (years)	Lecithotrophic	Planktotrophic	Ominvore	Detritivore	Unknown	Drift with Ocean Conditions	Reside in Nursery Areas	Inshore Molting\Mating Migration	Offshore Migration	Diel Migration	Noctunally Active	Unknown	Solitary	Burroughing	Mating Aggregation	Molting Aggregation	Defensive\Podding Aggregation	Spacial Aggregation	Other Aggreagtion	Unknown	Months Molting	Unknown	Months Mating	Unknown	Life Stage\Activity
Red King Crab	M	7-15+			●					●	●		●		●		●		fem	●			Dec-Jun		Jan-Jul		M
	LJ	4			●						●		●						●	●			Year Around				LJ
	EJ	2			●				●				●		●					●			Year Around				EJ
	L	0.2		●				●				●										●	Mar-Jul				L
	E	1	●																								E
Blue King Crab	M	8+			●					●	●		●		●		●			●			Jan-Jul		Jan-Jul		M
	LJ	4			●						●		●		●					●			Year Around				LJ
	EJ	2		●	●				●				●		●					●			Year Around				EJ
	L	0.2						●				●			●								Mar-Jun				L
	E	1-1.5	●																								E
Golden King Crab	M	6+			●									●						●			Year Around		Year Around		M
	LJ	4-5			●									●						●			Year Around				LJ
	EJ	2			●				●													●	Year Around				EJ
	L	0.2	●											●								●	Year Around				L
	E	1	●											●													E
Scarlet King Crab	M				●									●								●					M
	LJ				●									●								●					LJ
	EJ				●				●													●					EJ
	L		●											●								●					L
	E		●											●													E
Tanner Crab	M	6				●				●	●				●	●	●			●			Jan-Jun		Feb-Jun		M
	LJ	4				●					●				●	●							Jan-Dec				LJ
	EJ	2				●			●						●	●							Jan-Dec				EJ
	L	0.2		●				●				●								●			Jun-Jul				L
	E	1	●																								E
Snow Crab	M	6			●					●	●				●	●				●			Jun-Jul		Jun-Jul		M
	LJ	4			●						●				●	●							Year Around				LJ
	EJ	2			●				●						●	●							Year Around				EJ
	L	0.2		●				●				●								●			Jun-Jul				L
	E	1	●																								E
Grooved Tanner Crab	M						●							●								●		●		●	M
	LJ						●							●								●		●		●	LJ
	EJ						●							●								●		●		●	EJ
	L						●							●								●		●		●	L
	E						●							●								●		●		●	E
Traingle Tanner Crab	M						●							●								●		●		●	M
	LJ						●							●								●		●		●	LJ
	EJ						●							●								●		●		●	EJ
	L						●							●								●		●		●	L
	E						●							●								●		●		●	E

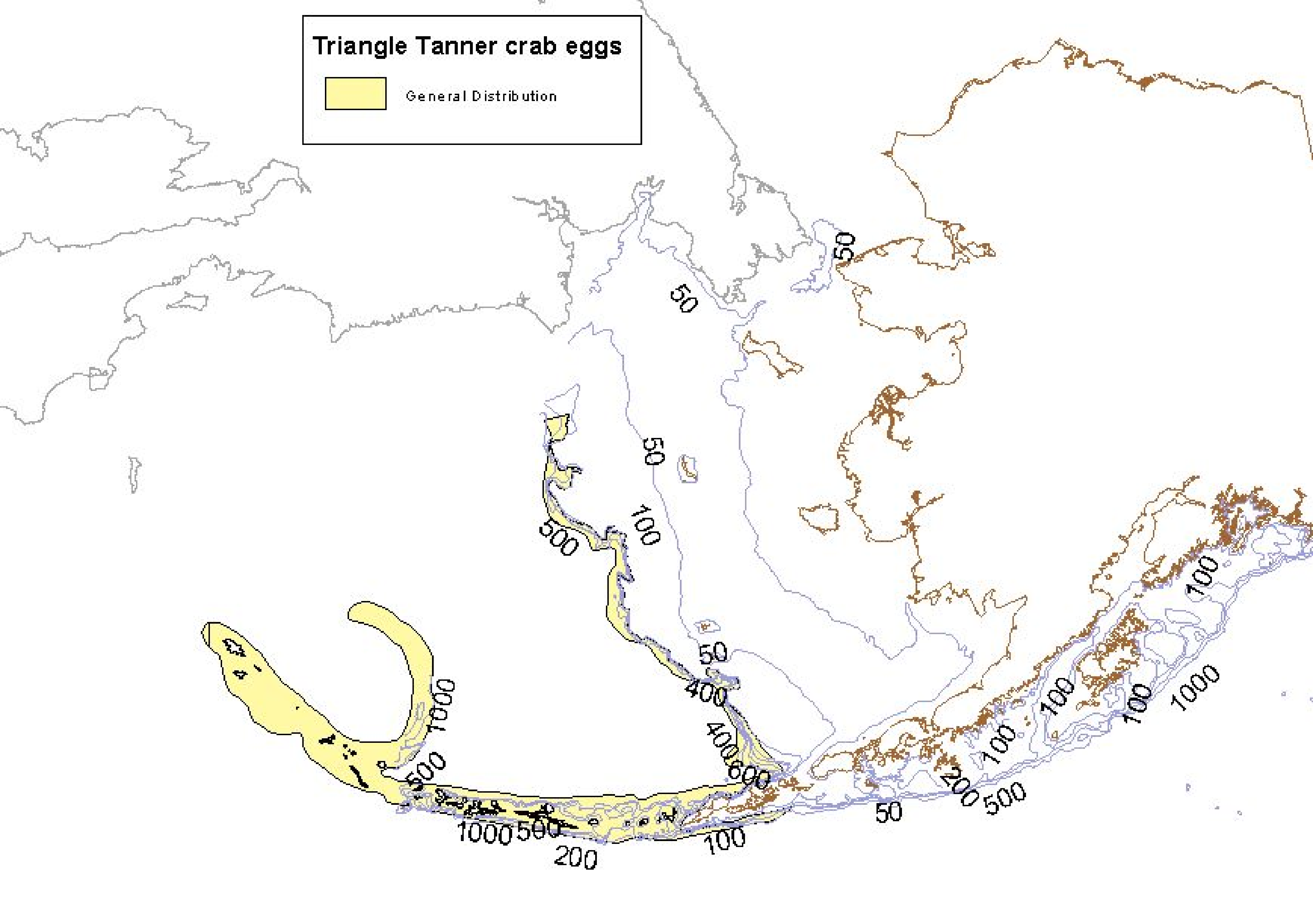
TABLE 1

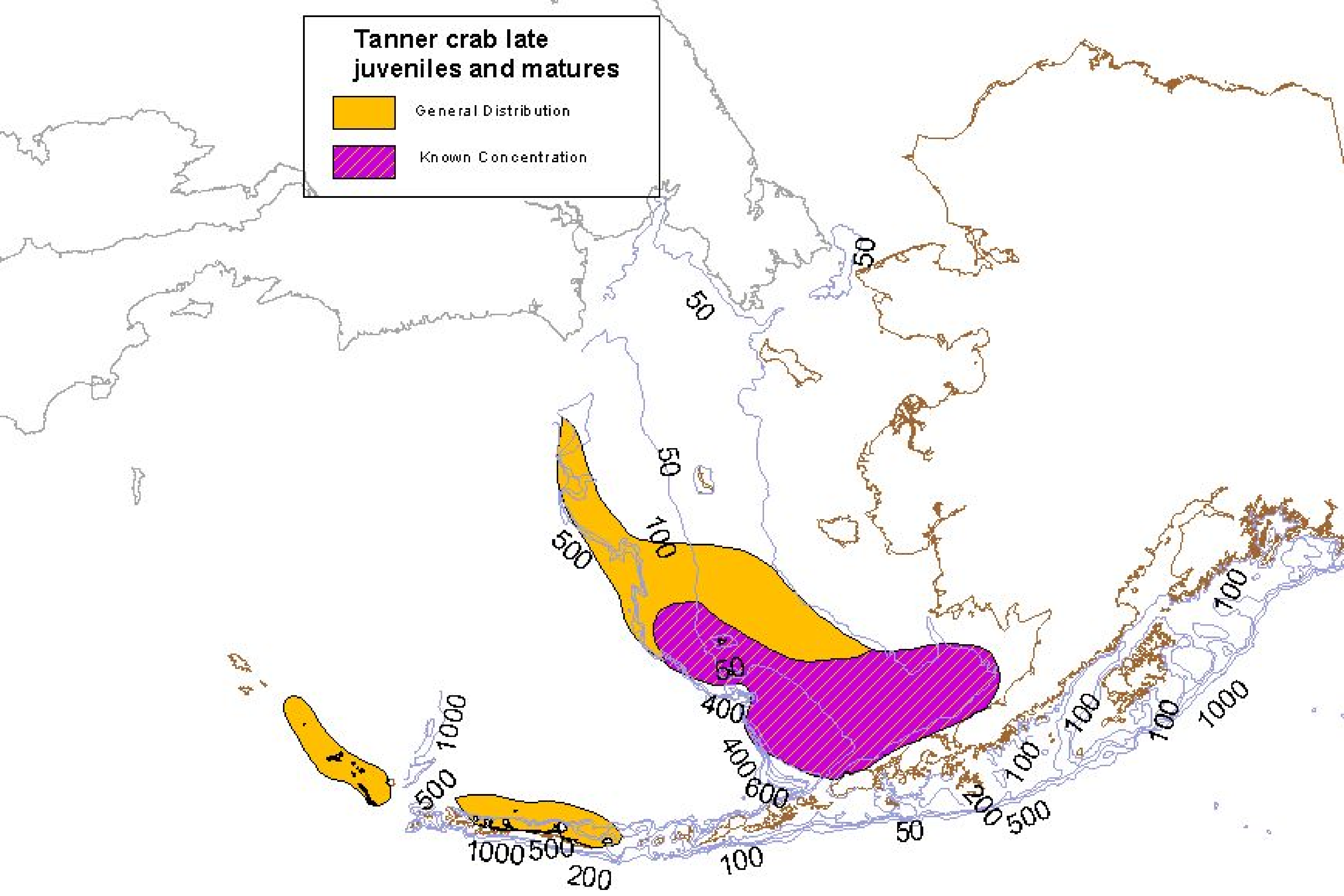
Habitat Associations for BSAI King and Tanner Crab Species

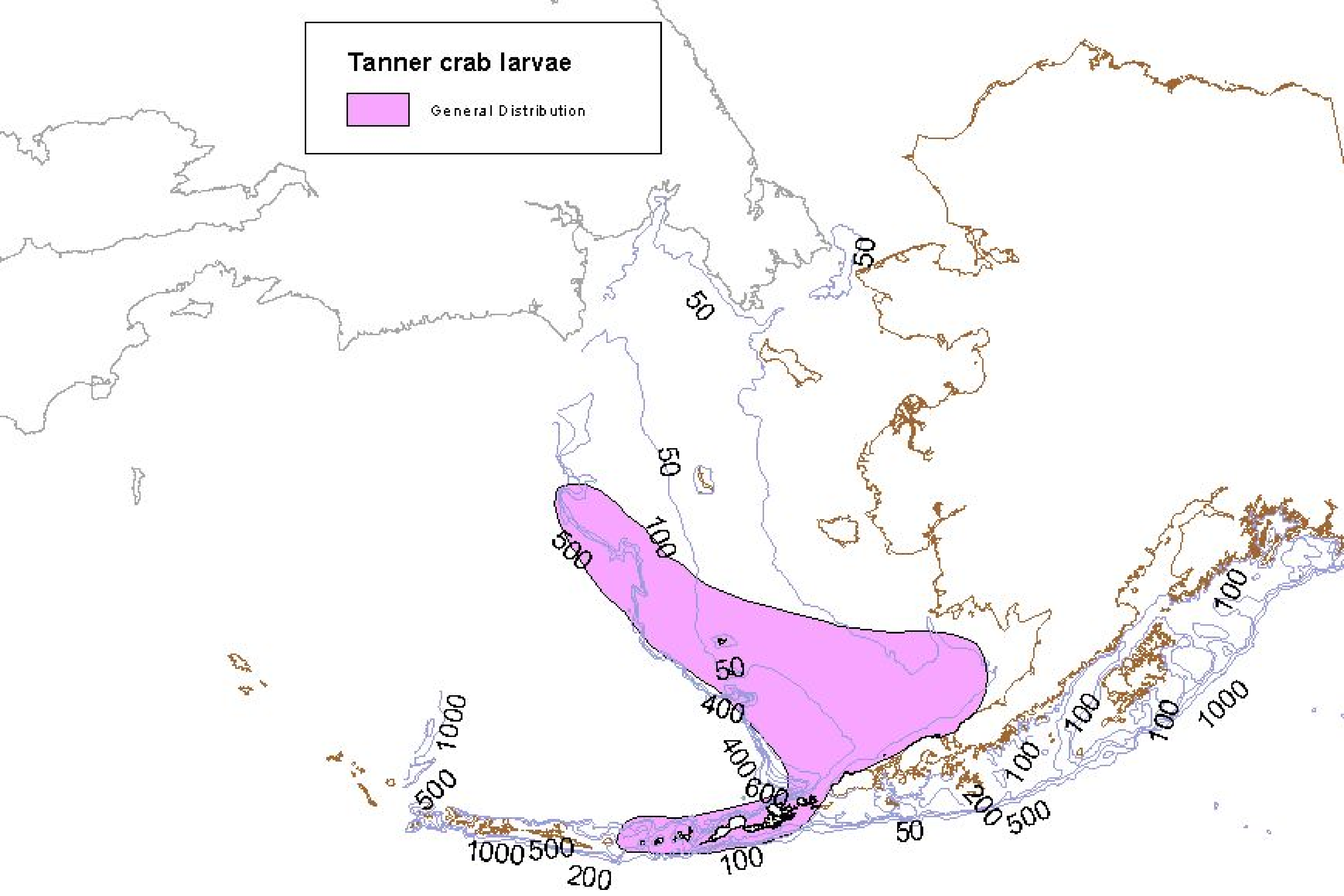
		Pelagic Domain										Benthic Domain											Structure										Substrate								Community											Ocean		
												Shelf					Slope			Canyon																																		
Species	Life Stage\Activity	Estuarine	Inshore Water (0-3 miles)	Offshore Water (3+ miles)	Surface Water	Midwater	Near Bottom	Vertical Depth (m)	Epipelagic (<200m)	Mesopelagic (200-1000m)	Bathypelagic (>1000m)	Bottom Depth Range (m)	Intertidal	Subtidal (<30m)	Middle (30-100m)	Outer (100-200m)	Upper (Break-500m)	Intermediate (500-1000m)	Lower (>500m)	Head (<100m)	Upper and Middle (100-500m)	Lower (>500m)	Bars	Banks	Sinks	Slumps\Rockfalls\Debris Field	Channels	Ledges	Pinnacles	Reefs	Vertical Walls	Man-made	Organic Debris	Mud\Clay\Silt	Sand\Granule	Gravel	Pebble	Cobble	Boulder	Bedrock	Algal Cover	Anenomes	Enchinoderms	Corals (soft)	Mollusca	Drift Algae\Kelp	Kelp Forest	Polychaetes	Sea Grasses	Sea Onions	Tunicates	Temperature (Celsius)	Salinity (ppt)	Life Stage\Activity
Red King Crab	M											3-300		●	●	●	●						●	●	●	●	●	●		●			●	●	●	●	●	●				●	●	●	●	●	●	●		●	●	<6°	>25	M
	LJ											0-200	●	●	●		●						●	●	●	●	●	●		●			●	●	●	●	●	●			●	●	●	●	●	●	●	●		●	●			LJ
	EJ											0-50	●	●	●	●	●																																				>20	EJ
	L	●	●	●	●	●	●					0-100																																								<12	>20	L
	E											0-200	●	●	●	●	●						●	●	●	●	●	●		●			●	●	●	●	●	●				●	●	●	●	●	●	●		●	●	<6	>25	E
Blue King Crab	M											0-200		●	●	●							●	●	●	●	●	●	●	●		●	●	●	●	●	●	●	●			●	●	●	●	●	●	●		●	●	<6	>25	M
	LJ											0-200		●	●	●							●	●	●	●	●	●	●	●		●	●	●	●	●	●	●	●			●	●	●	●	●	●	●		●	●			LJ
	EJ											<50	●	●	●								●	●	●	●	●	●	●	●		●	●	●	●	●	●	●	●			●	●	●	●	●	●	●		●	●			EJ
	L	●	●	●	●	●	●		●			0-100																																										L
	E											0-100		●	●								●	●	●	●	●	●	●	●		●	●	●	●	●	●	●	●			●	●	●	●	●	●	●		●	●			E
Golden King Crab	M											100-1000				●	●	●	●		●	●		●		●	●	●	●	●	●				●	●	●	●	●	●		●	●	●	●			●				<5	>30	M
	LJ											>1000							●			●		●		●	●	●	●	●	●				●	●	●	●	●	●		●	●	●	●			●				<5	>30	LJ
	EJ											>1000							●			●																														<5	>30	EJ
	L						●			●																																										<5	>30	L
	E											100-1000				●	●	●	●		●	●		●		●	●	●	●	●	●				●	●	●	●	●	●		●	●	●	●			●				<5	>30	E
Scarlet King Crab	M											300+					●	●	●		●	●																														<4	>33	M
	LJ																																																					LJ
	EJ																																																					EJ
	L																																																					L
	E											300+					●	●	●		●	●																														<4	>33	E
Tanner Crab	M											3-700		●	●	●	●	●	●	●	●	●	●	●	●	●	●					●	●	●	●	●	●	●				●	●	●	●	●	●	●		●	●	<10	>30	M
	LJ											3-200		●	●	●				●	●		●	●	●	●	●					●	●	●	●	●	●	●				●	●	●	●	●	●	●		●	●	<10	>30	LJ
	EJ											3-200		●	●	●				●	●		●	●	●	●	●					●	●	●	●	●	●	●				●	●	●	●	●	●	●		●	●	<10	>30	EJ
	L	●	●	●	●	●	●	0-100	●																																											<10	>30	L
	E											3-700		●	●	●	●	●	●	●	●	●	●	●	●	●	●					●	●	●	●	●	●	●				●	●	●	●	●	●	●		●	●	<10	>30	E
Snow Crab	M											25-400		●	●	●	●	●	●	●	●	●	●	●	●	●	●					●	●	●	●	●	●	●				●	●	●	●	●	●	●		●	●	<10	>30	M
	LJ											25-200		●	●	●	●	●	●	●	●	●	●	●	●	●	●					●	●	●	●	●	●	●				●	●	●	●	●	●	●		●	●	<10	>30	LJ
	EJ											25-150		●	●	●	●	●	●	●	●	●	●	●	●	●	●					●	●	●	●	●	●	●				●	●	●	●	●	●	●		●	●	<10	>30	EJ
	L		●	●	●	●	●	0-100																																												<10	>30	L
	E													●	●	●	●	●	●	●	●	●	●	●	●	●	●					●	●	●	●	●	●	●				●	●	●	●	●	●	●		●	●	<10	>30	E
Grooved Tanner Crab	M											200-1000				●	●	●			●	●																																M
	LJ																																																					LJ
	EJ																																																					EJ
	L																																																					L
	E																																																					E
Traingle Tanner Crab	M											200-1000				●	●	●			●	●																																M
	LJ																																																					LJ
	EJ																																																					EJ
	L																																																					L
	E																																																					E

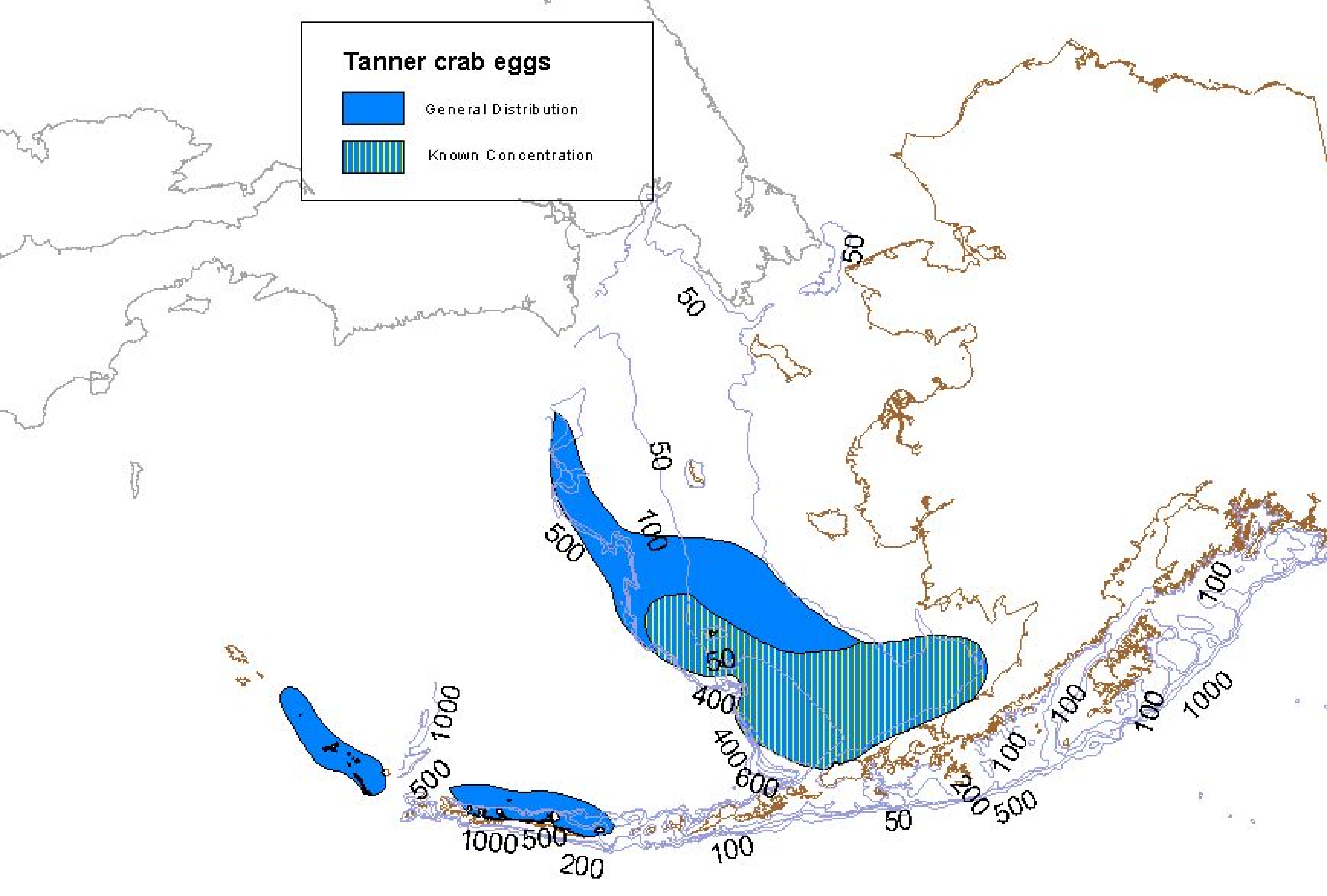


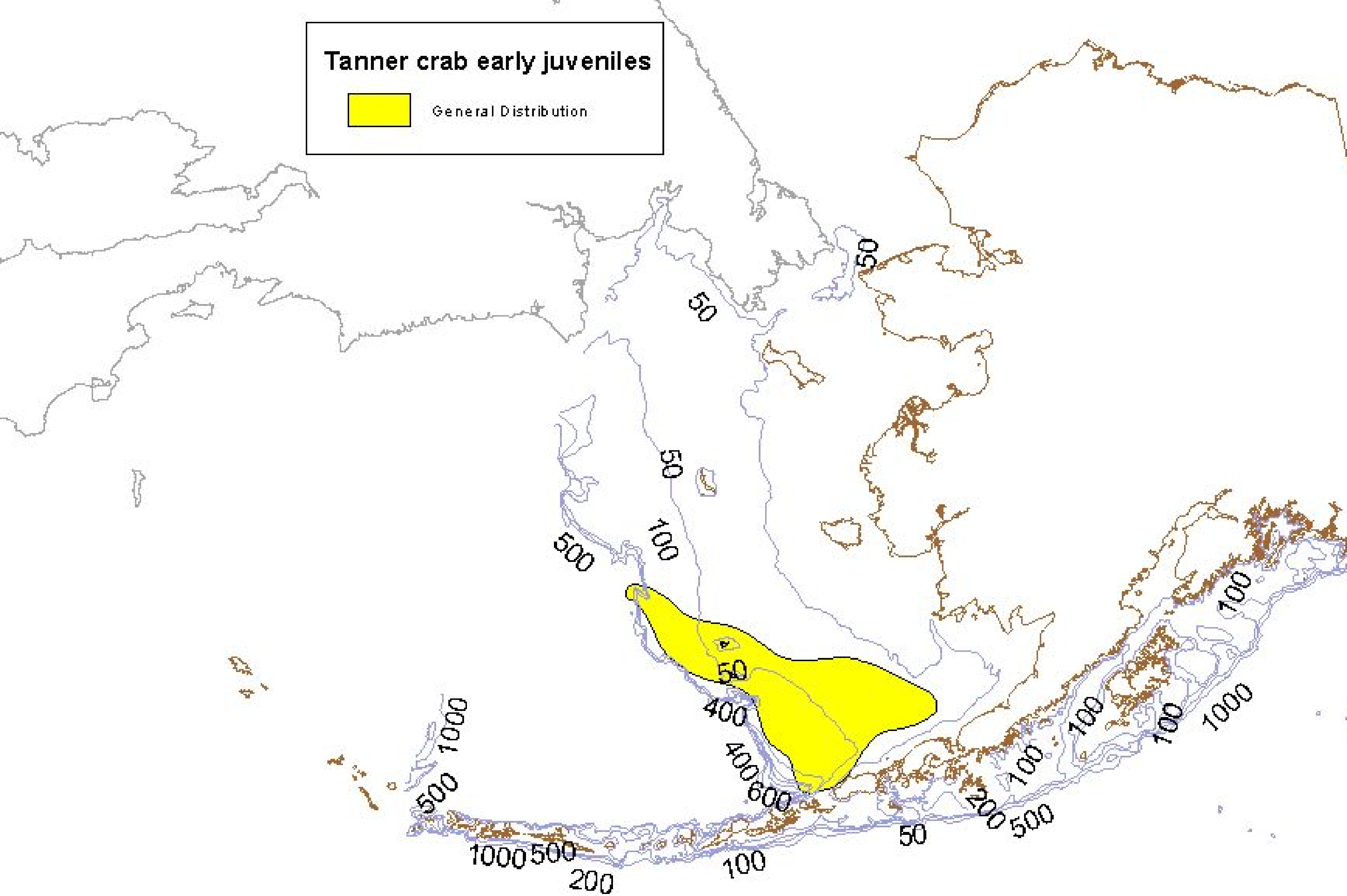
Blue king crab early juveniles
General Distribution

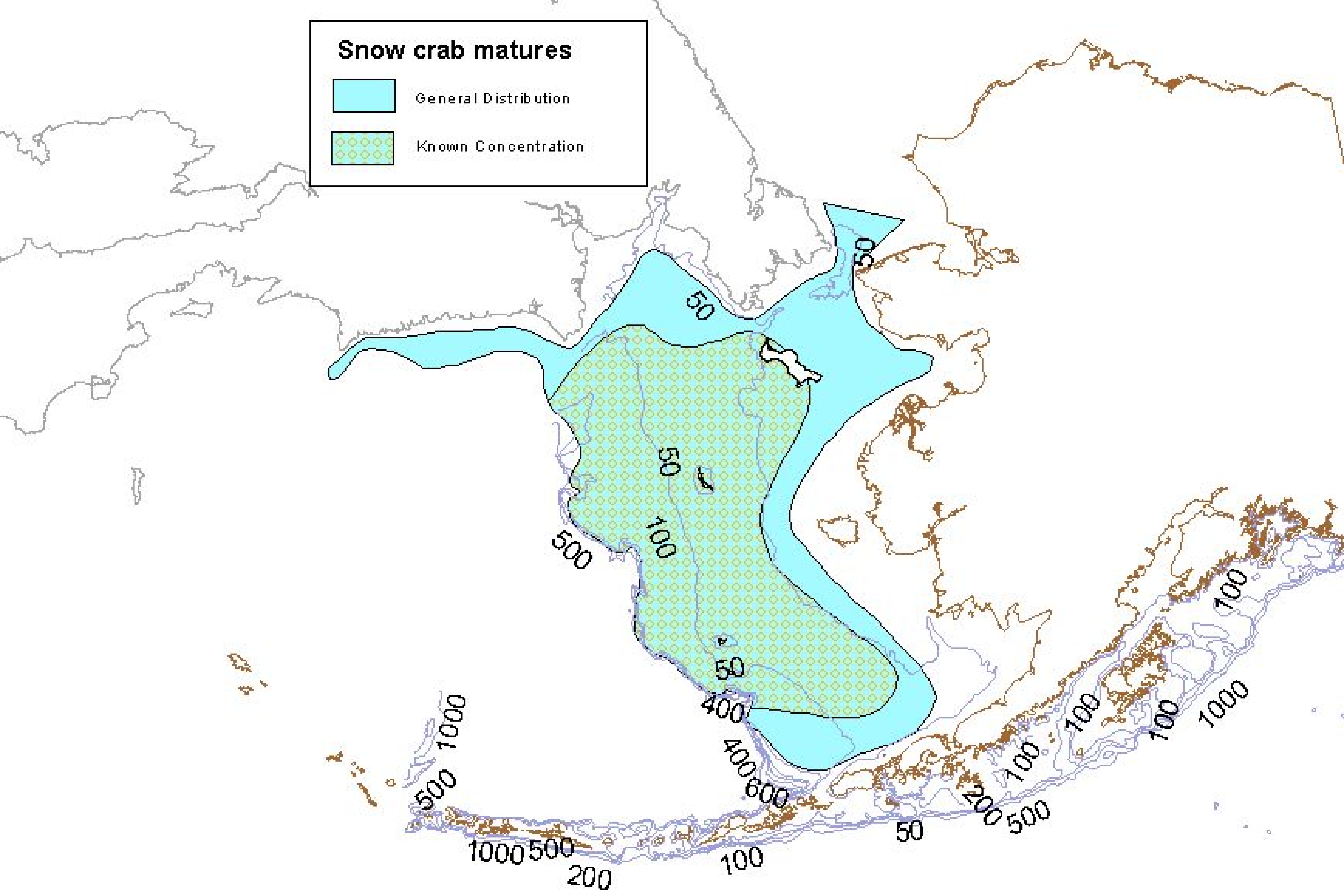

Triangle Tanner crab eggs
General Distribution
50
50
50
100
500
50
400
400
600
1000
500
1000
500
200
100
50
200
500
100
100
100
100
1000

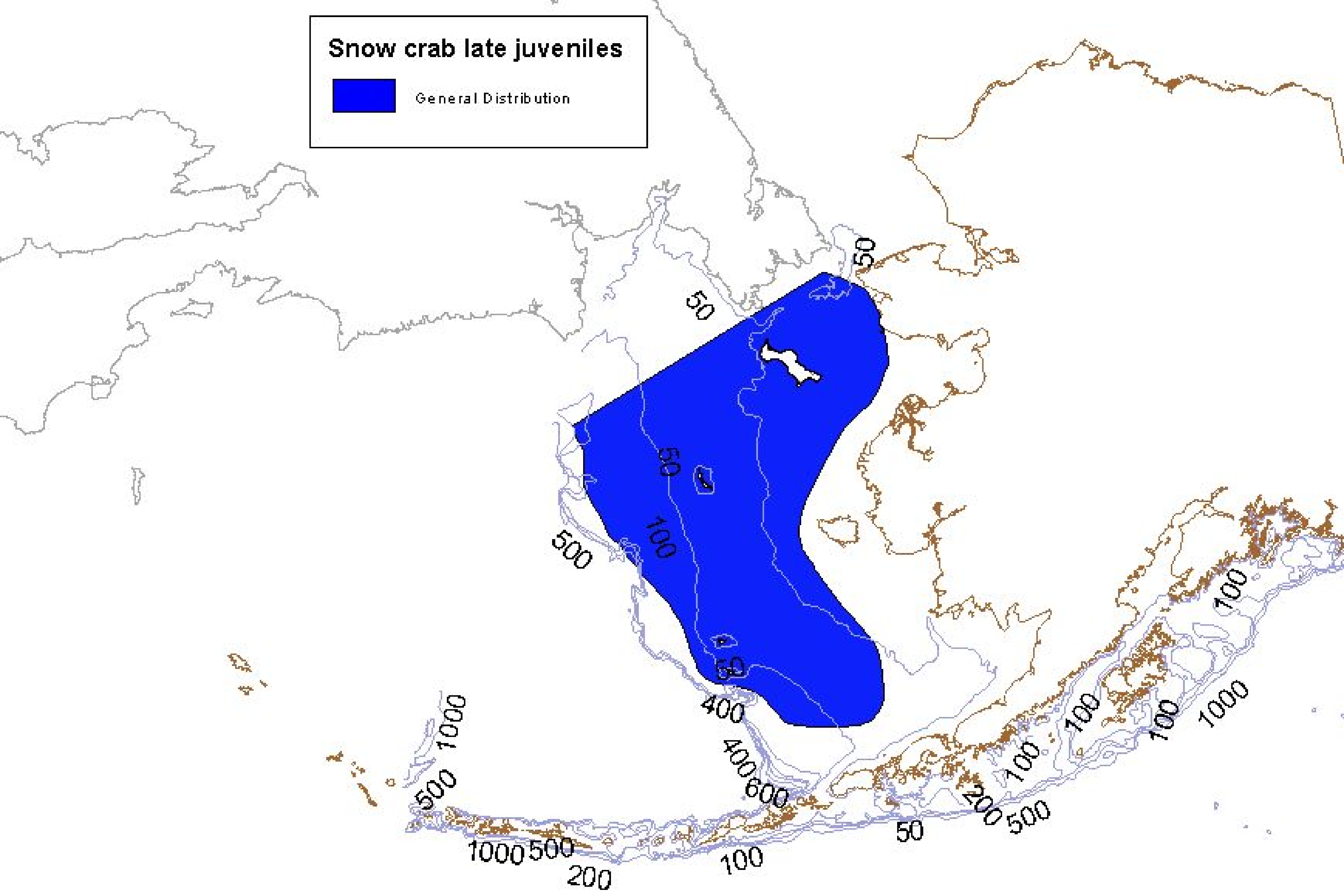

Tanner crab late juveniles and matures
General Distribution
Known Concentration
50
50
50
100
500
50
400
400
600
1000
500
1000
500
200
100
50
200
500
100
100
100
100
1000

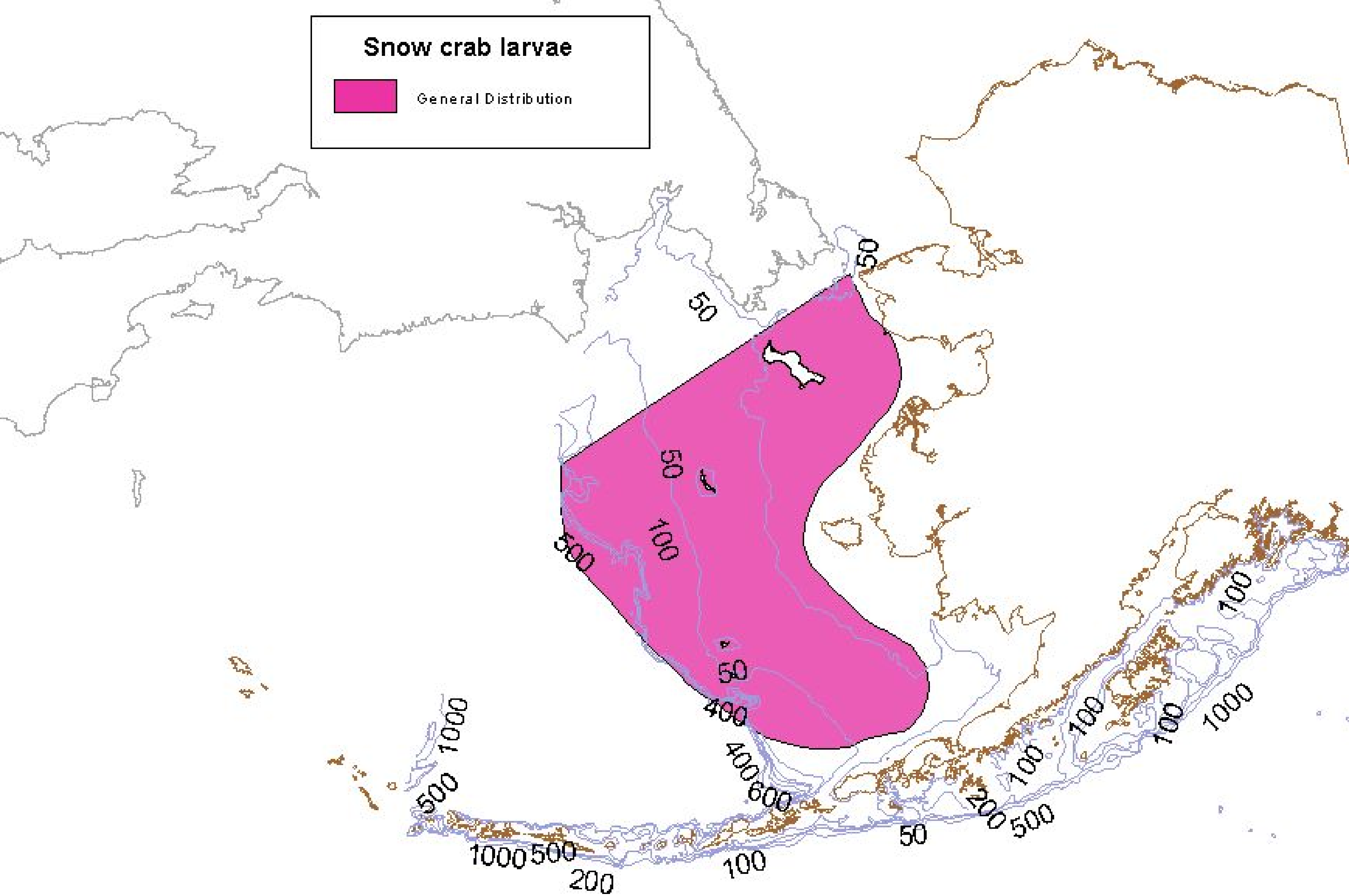

Tanner crab larvae
General Distribution
50
50
50
100
500
50
400
400
600
1000
500
1000
500
200
100
50
200
500
100
100
100
100
1000

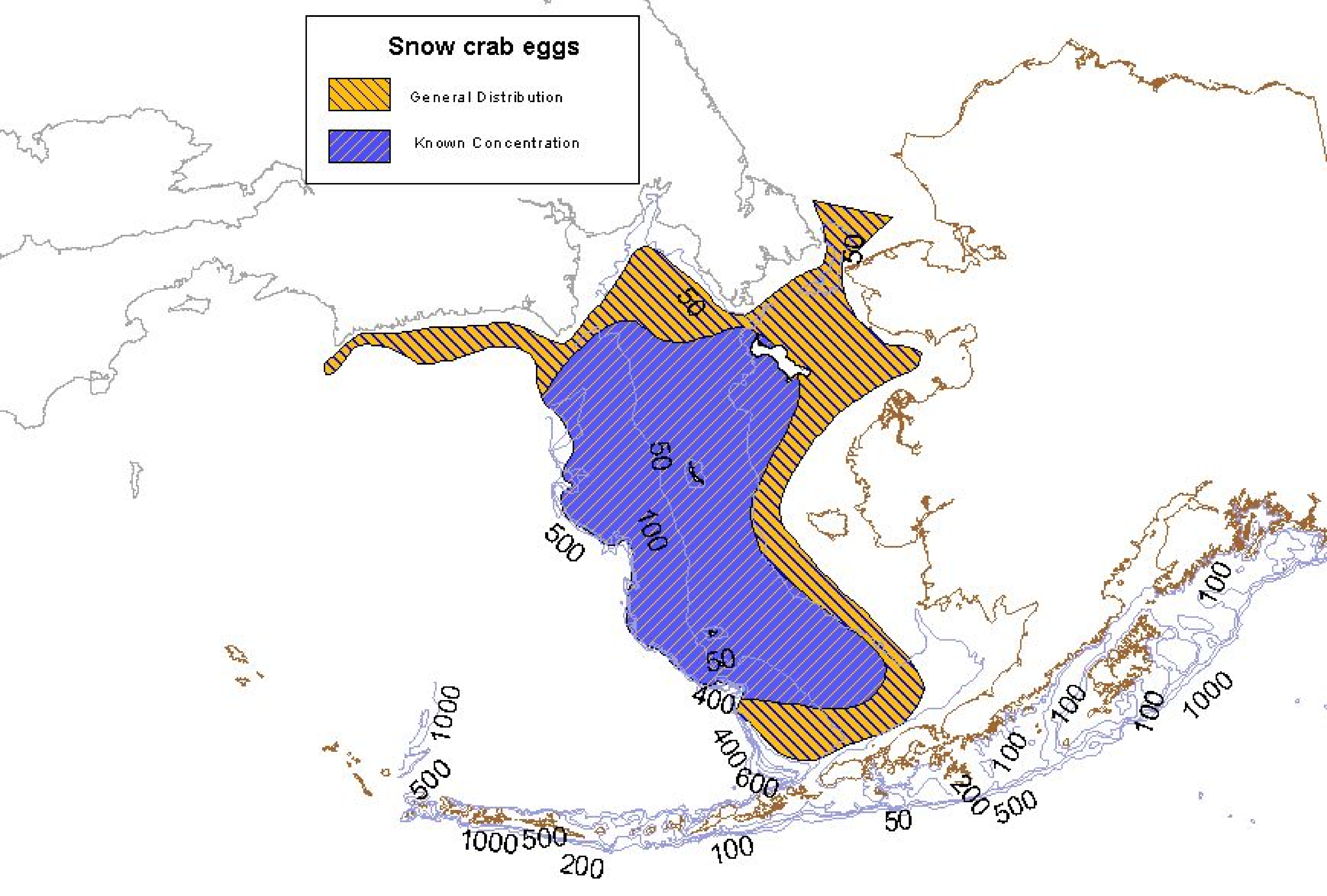

Tanner crab eggs
General Distribution
Known Concentration
50
50
50
100
500
50
400
400
600
1000
500
1000
500
200
100
50
200
500
100
100
100
100
1000

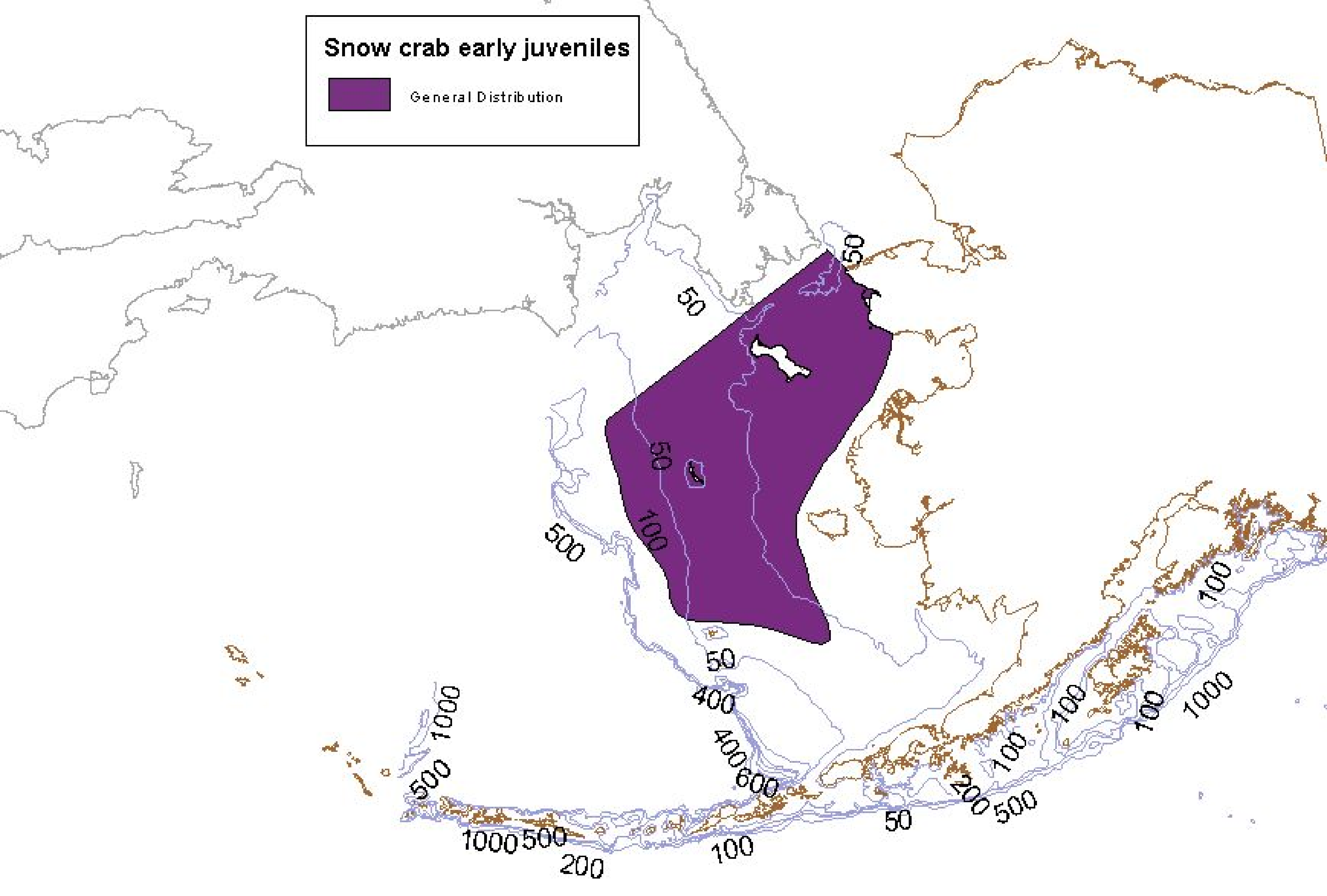

Tanner crab early juveniles
General Distribution
50
50
50
100
500
50
400
400
600
1000
500
1000
500
200
100
50
200
500
100
100
100
100
1000


Snow crab matures
General Distribution
Known Concentration
50
50
50
100
500
50
400
400
600
1000
500
1000
500
200
100
50
200
500
100
100
100
100
1000

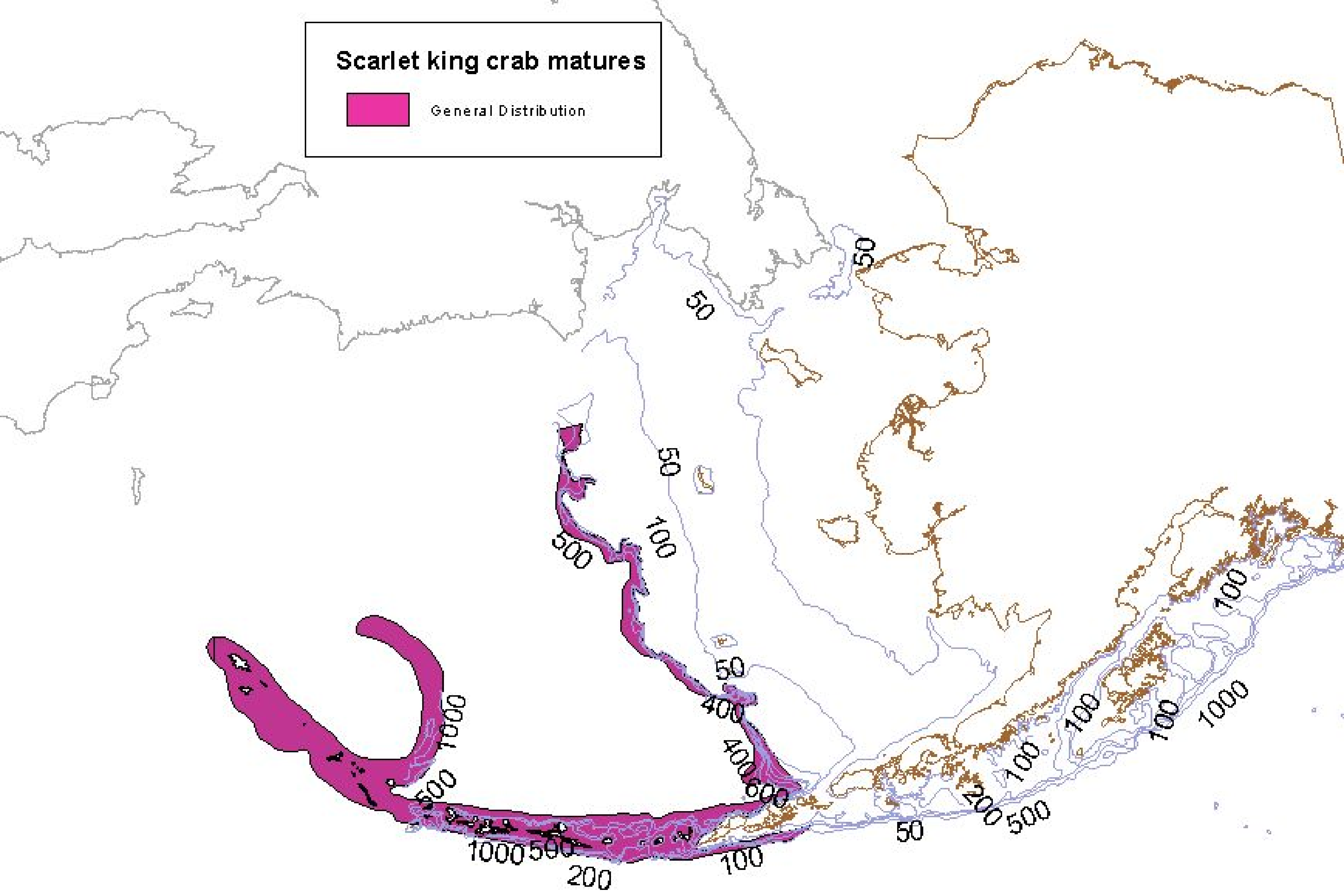

Snow crab late juveniles
General Distribution

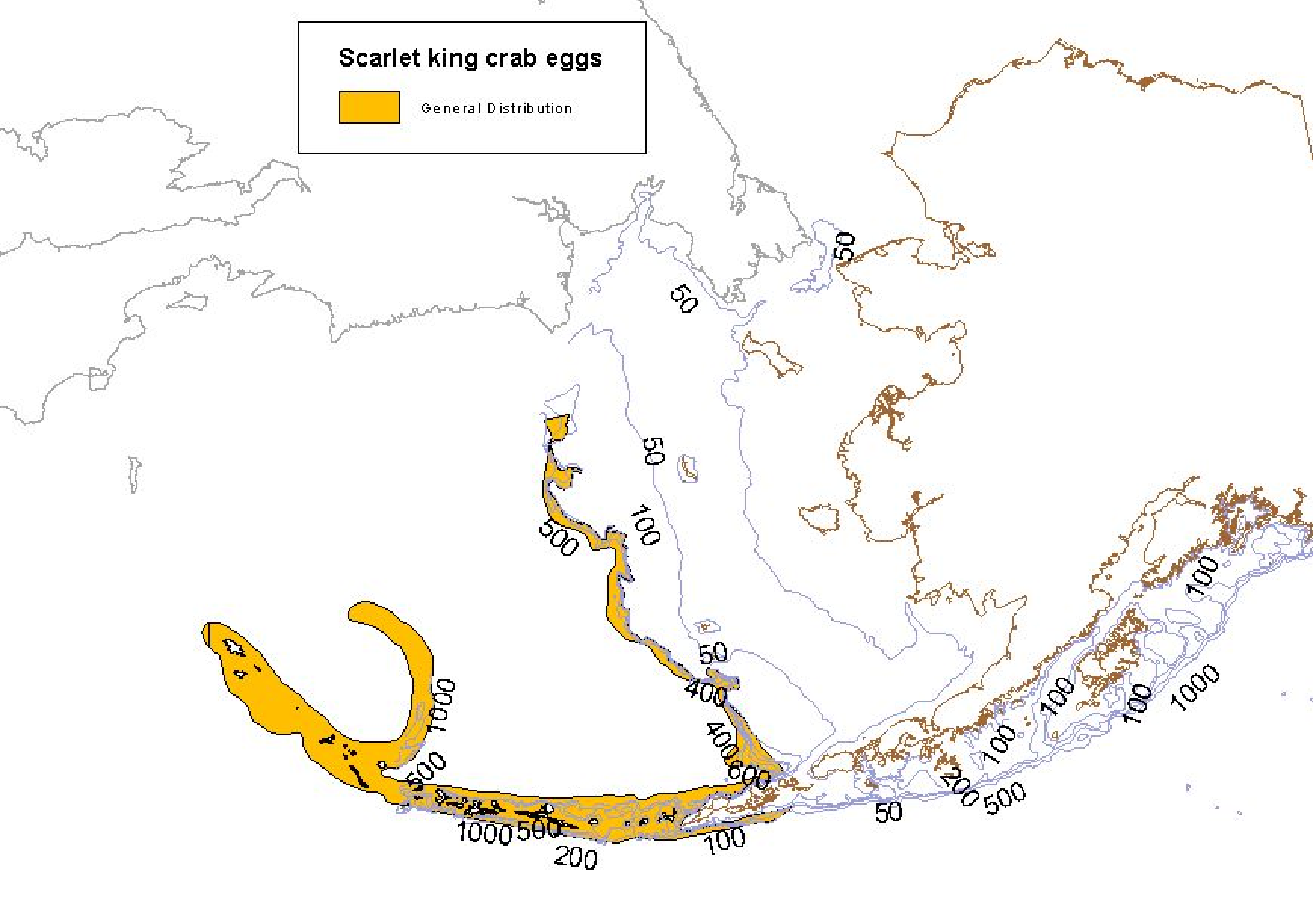

Snow crab larvae
General Distribution
50
50
50
100
500
50
400
400
600
1000
500
1000
500
200
100
50
200
500
100
100
100
100
1000

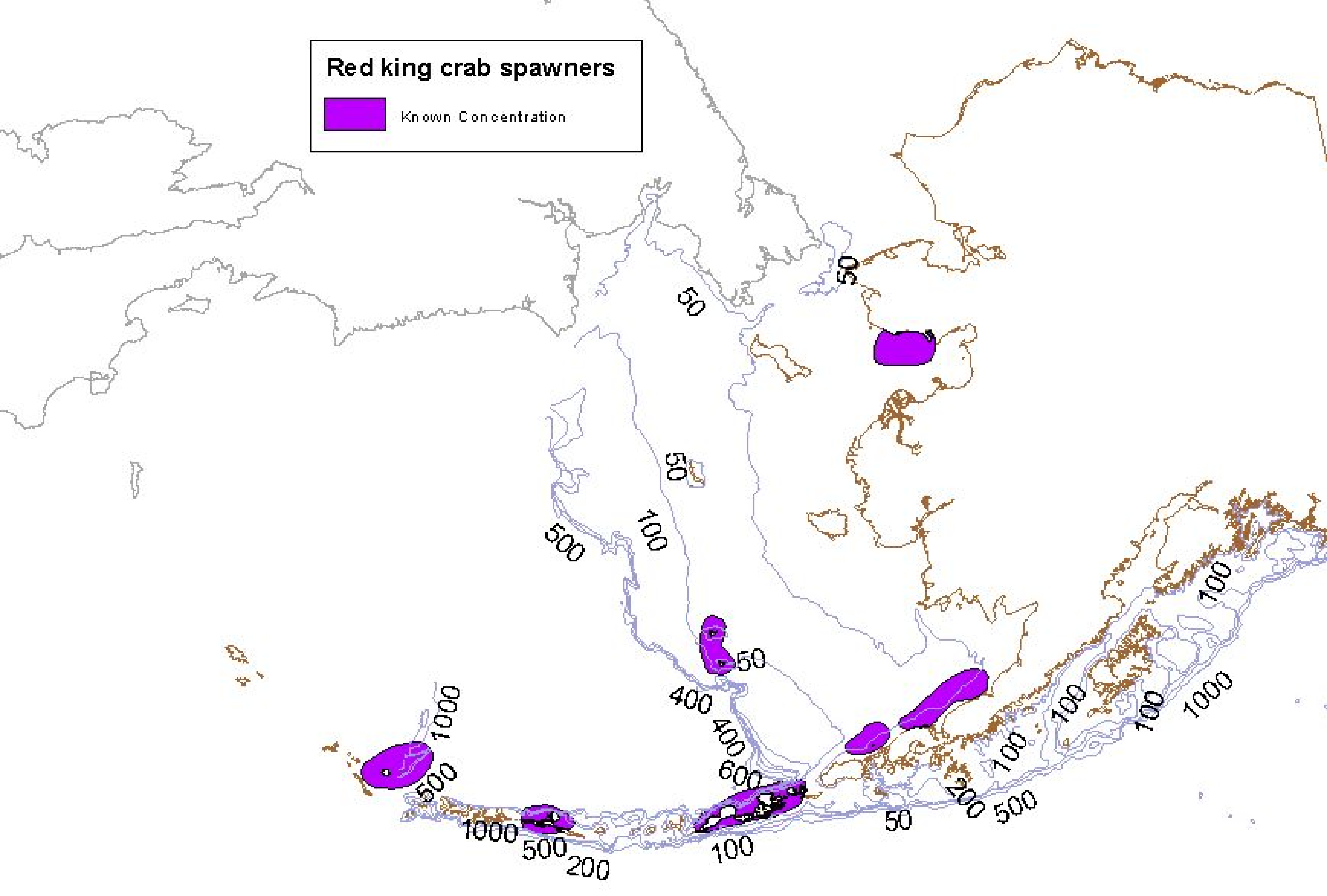

Snow crab eggs
General Distribution
Known Concentration
50
50
50
100
500
50
400
400
600
1000
500
1000
500
200
100
50
200
500
100
100
100
100
1000

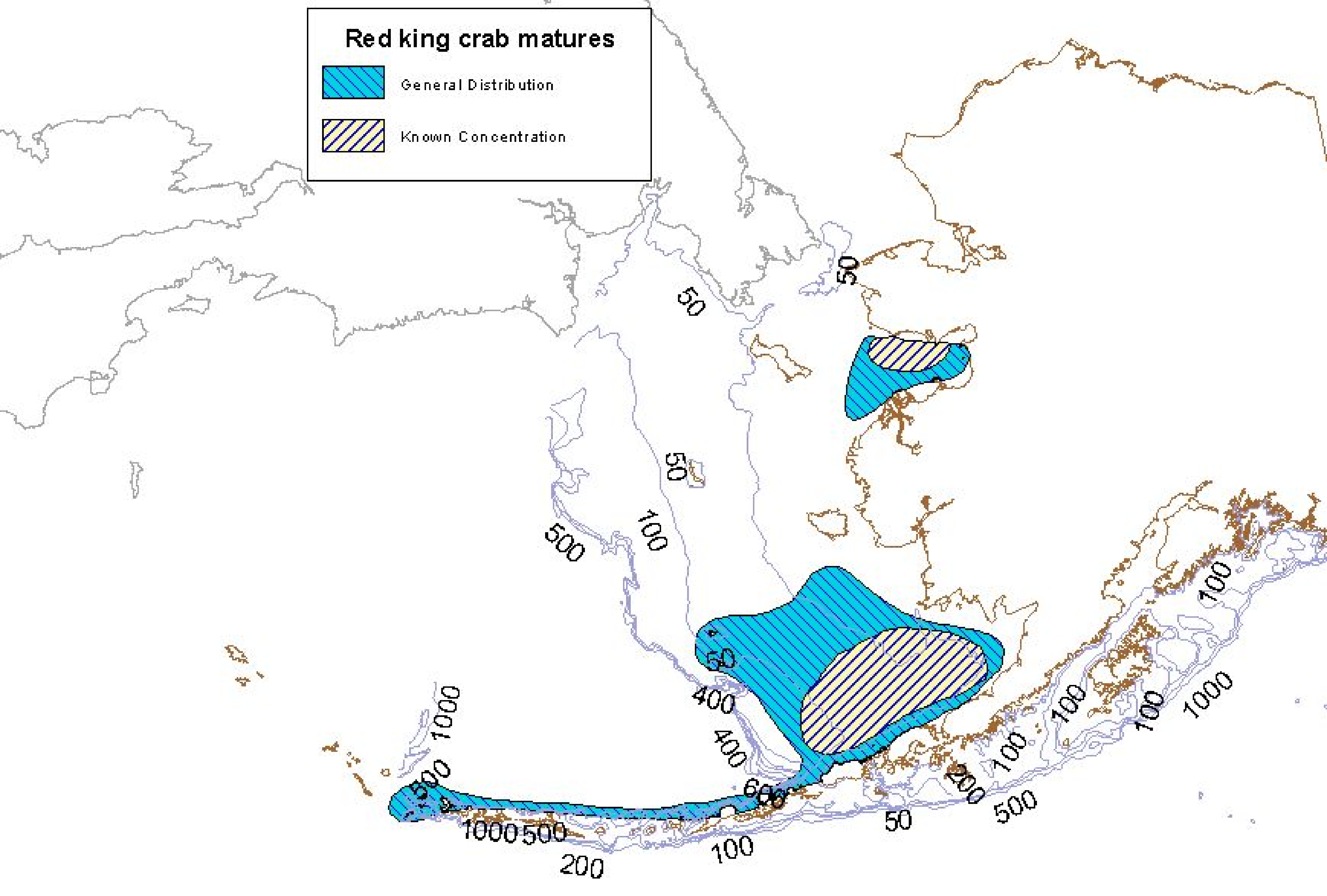


Snow crab early juveniles
General Distribution
50
50
50
100
500
50
400
400
600
1000
500
1000
500
200
100
50
200
500
100
100
100
100
1000

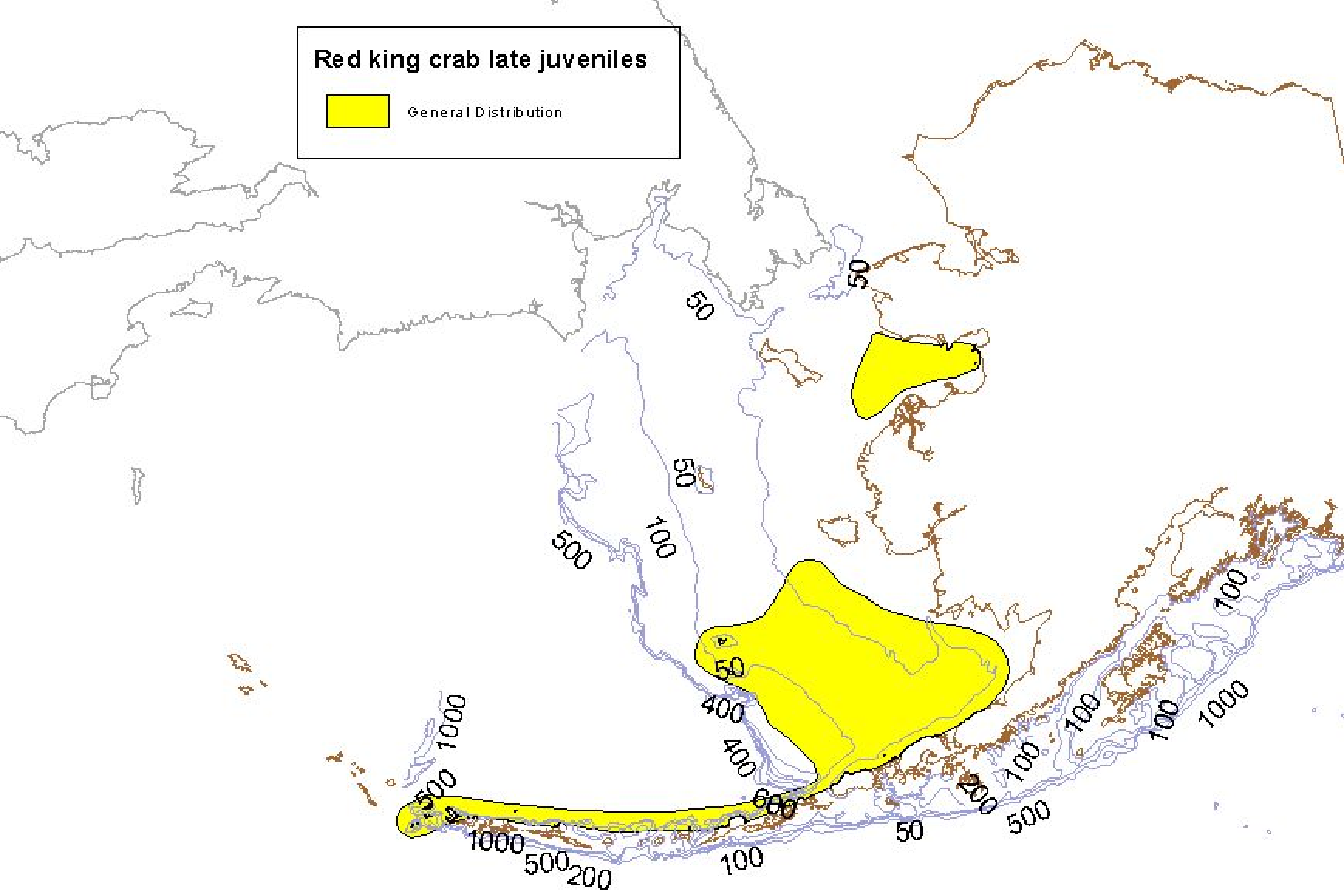

Scarlet king crab matures
General Distribution
50
50
50
100
500
50
1000
500
400
400
600
1000
500
200
100
50
100
100
100
100
200
500
1000


Scarlet king crab eggs
General Distribution
50
50
50
100
500
50
400
400
600
1000
500
1000
500
200
100
50
200
500
100
100
100
100
1000

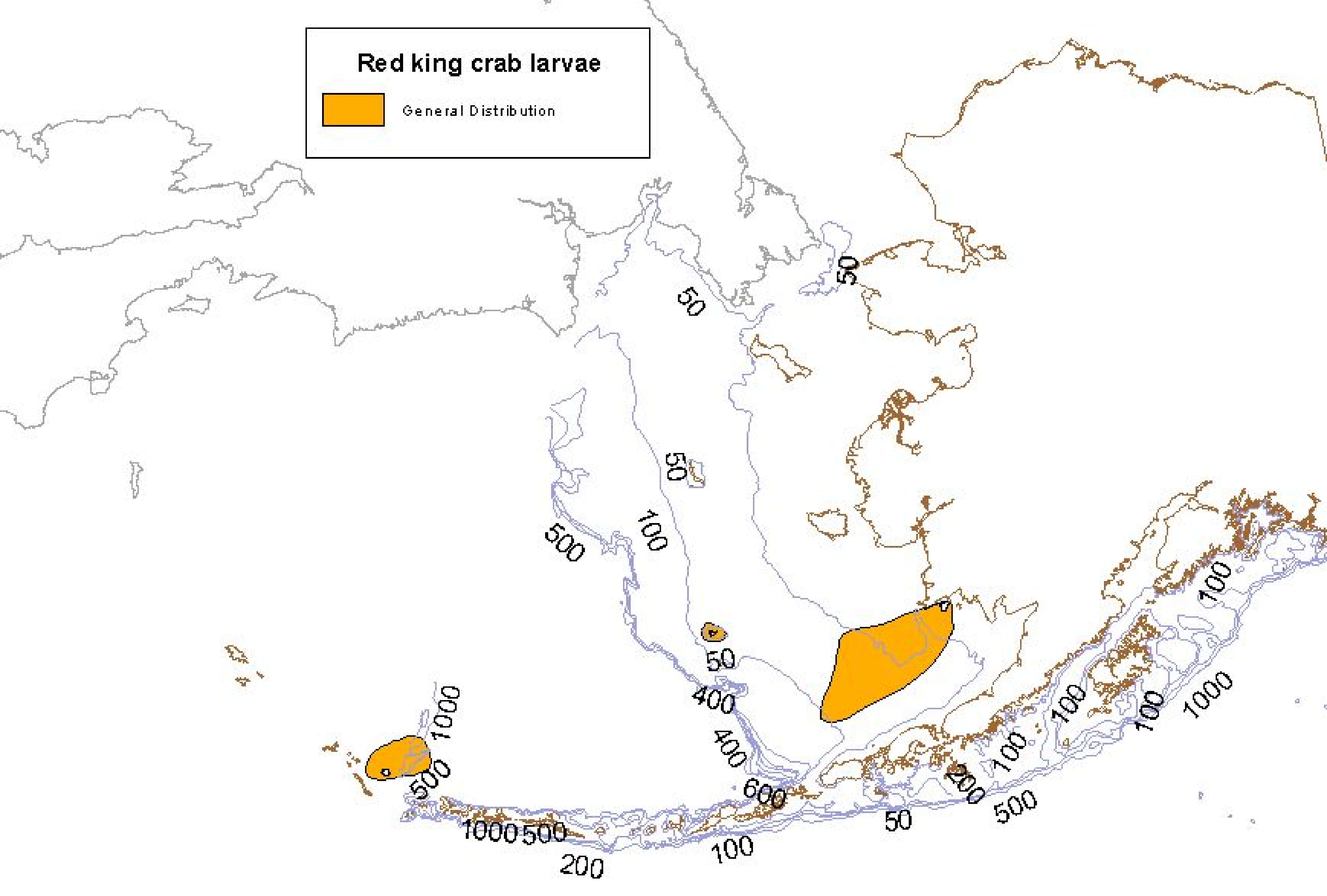

Red king crab spawners
Known Concentration
50
50
50
100
500
50
400
400
600
1000
500
1000
500
200
100
50
200
500
100
100
100
1000
100

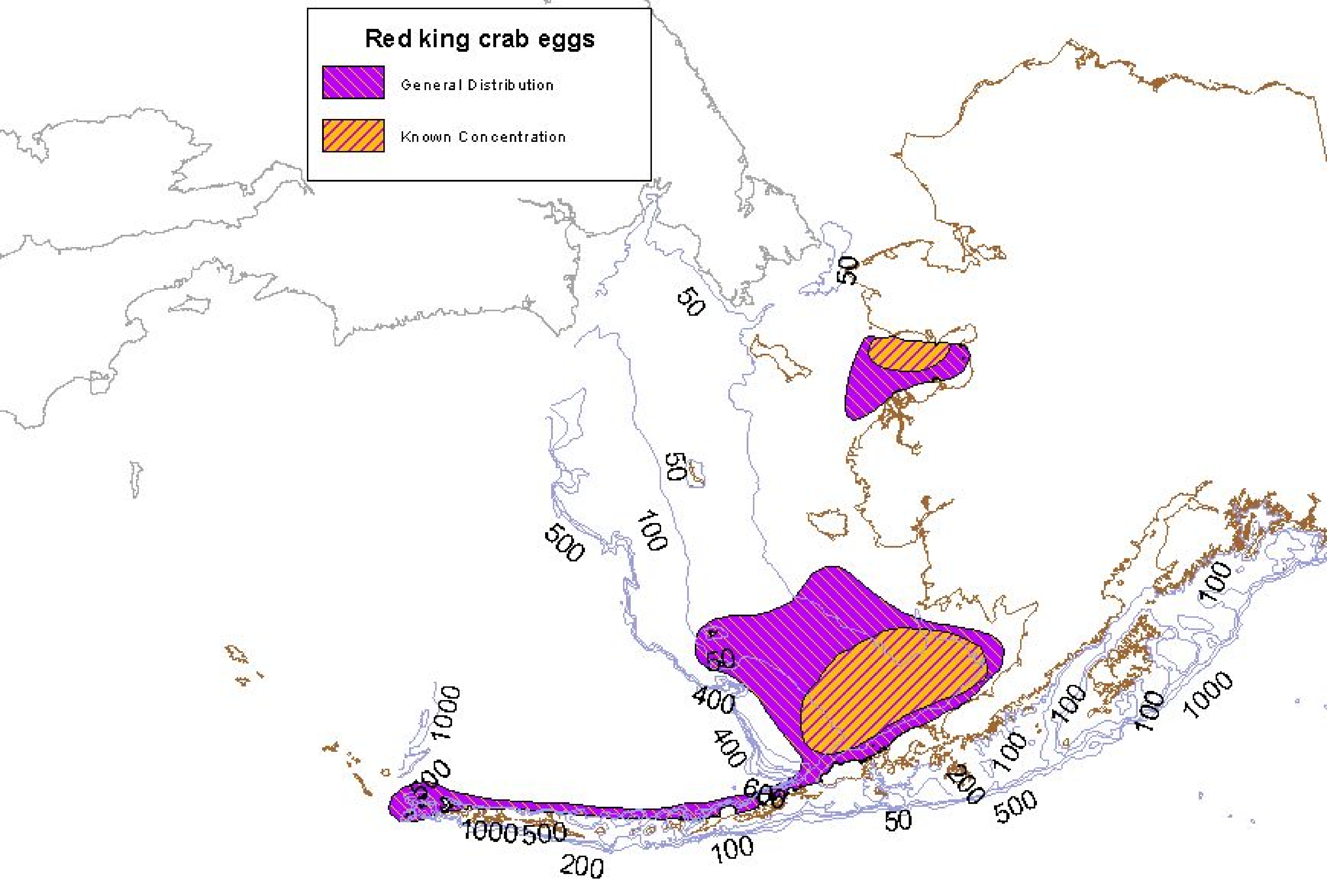


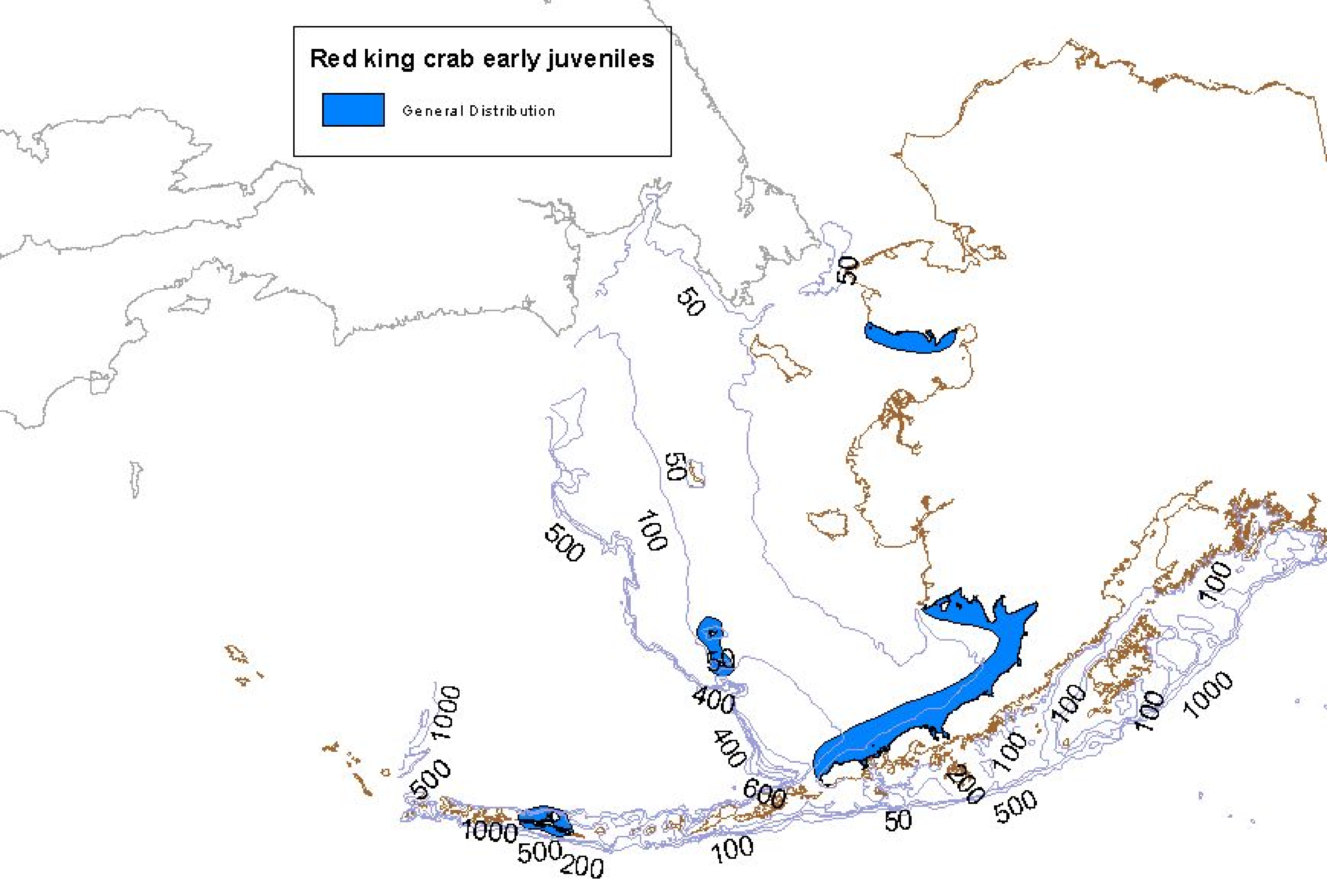
Red king crab matures
General Distribution
Known Concentration

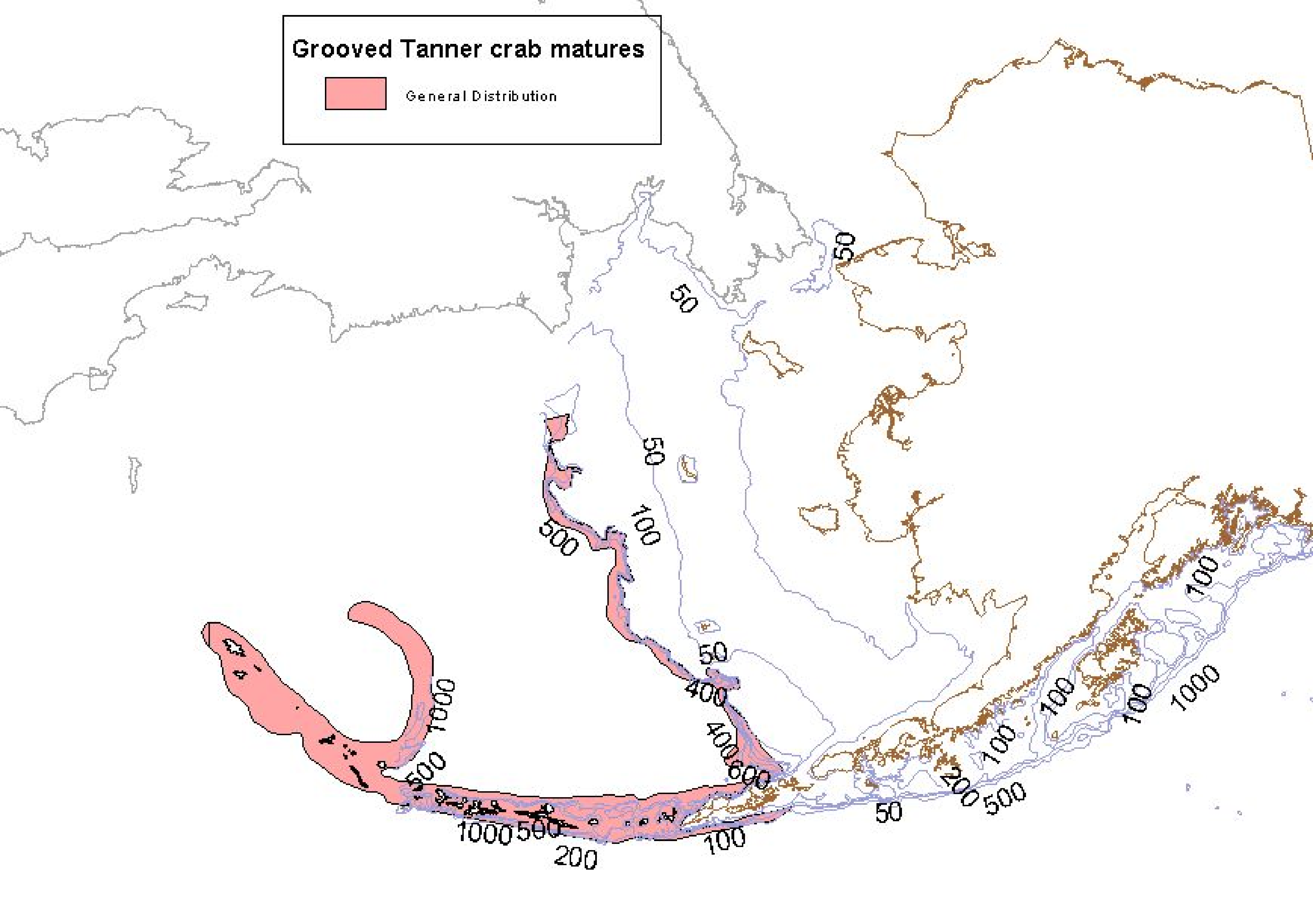


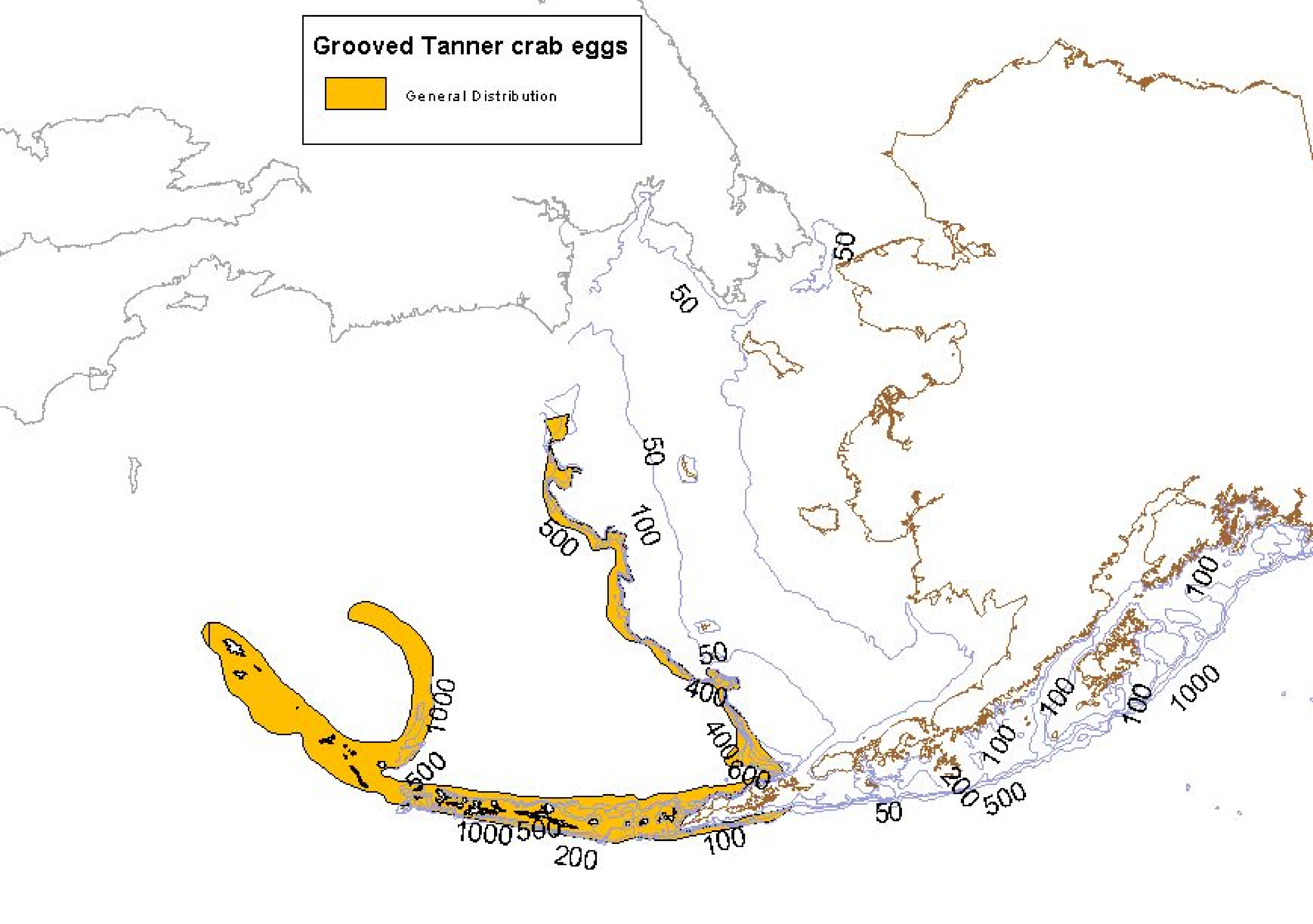
Red king crab late juveniles
General Distribution
50
50
50
100
500
50
400
400
1000
500
1000
500
200
100
50
200
500
100
100
100
1000
100

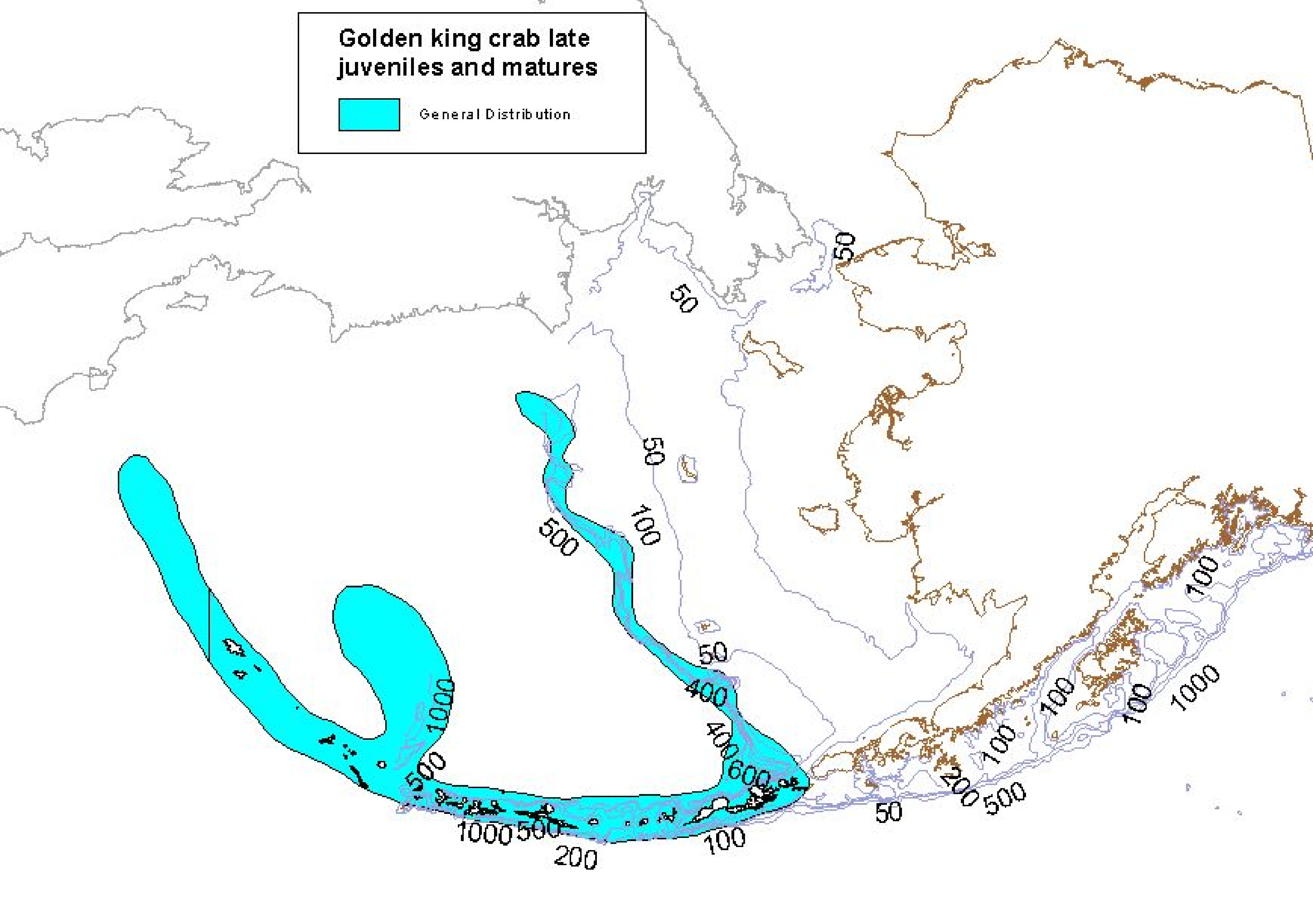

Red king crab larvae
General Distribution

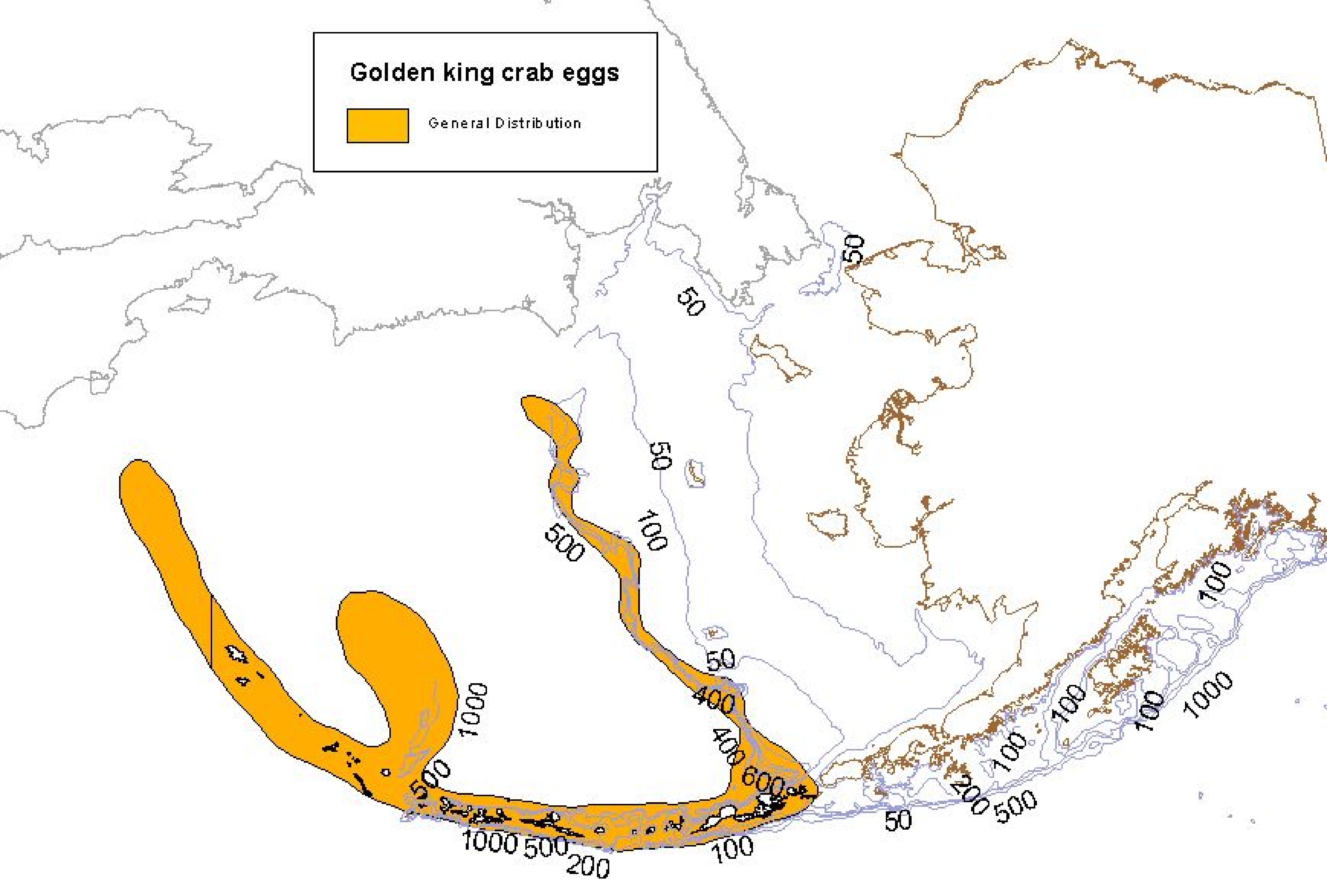

Red king crab eggs
General Distribution
Known Concentration
50
50
50
100
500
400
400
1000
500
1000500
200
100
50
200
500
100
100
100
1000
100

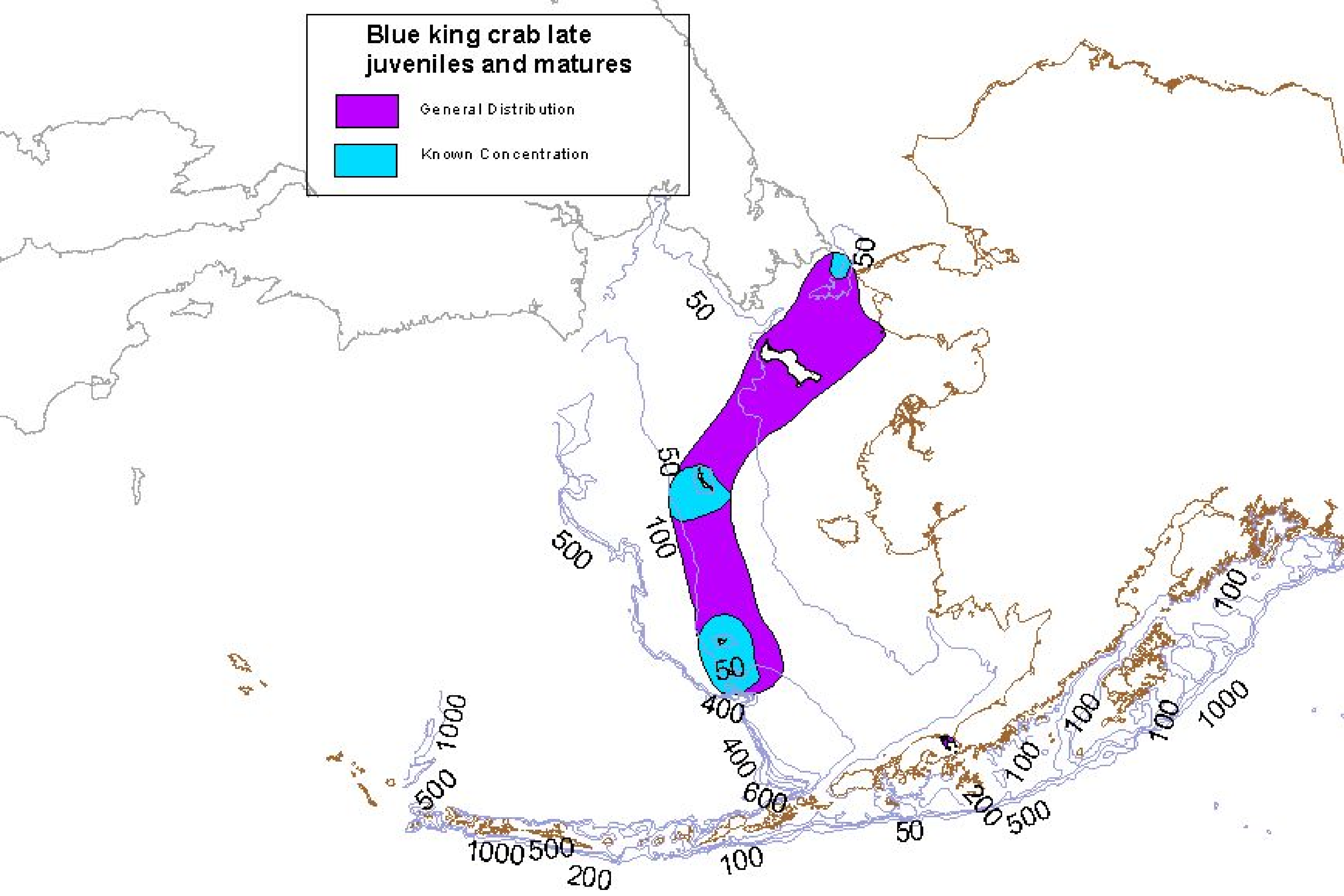

Red king crab early juveniles
General Distribution
50
50
50
100
500
400
400
600
1000
500
1000
500
200
100
50
200
100
100
100
500
1000
100

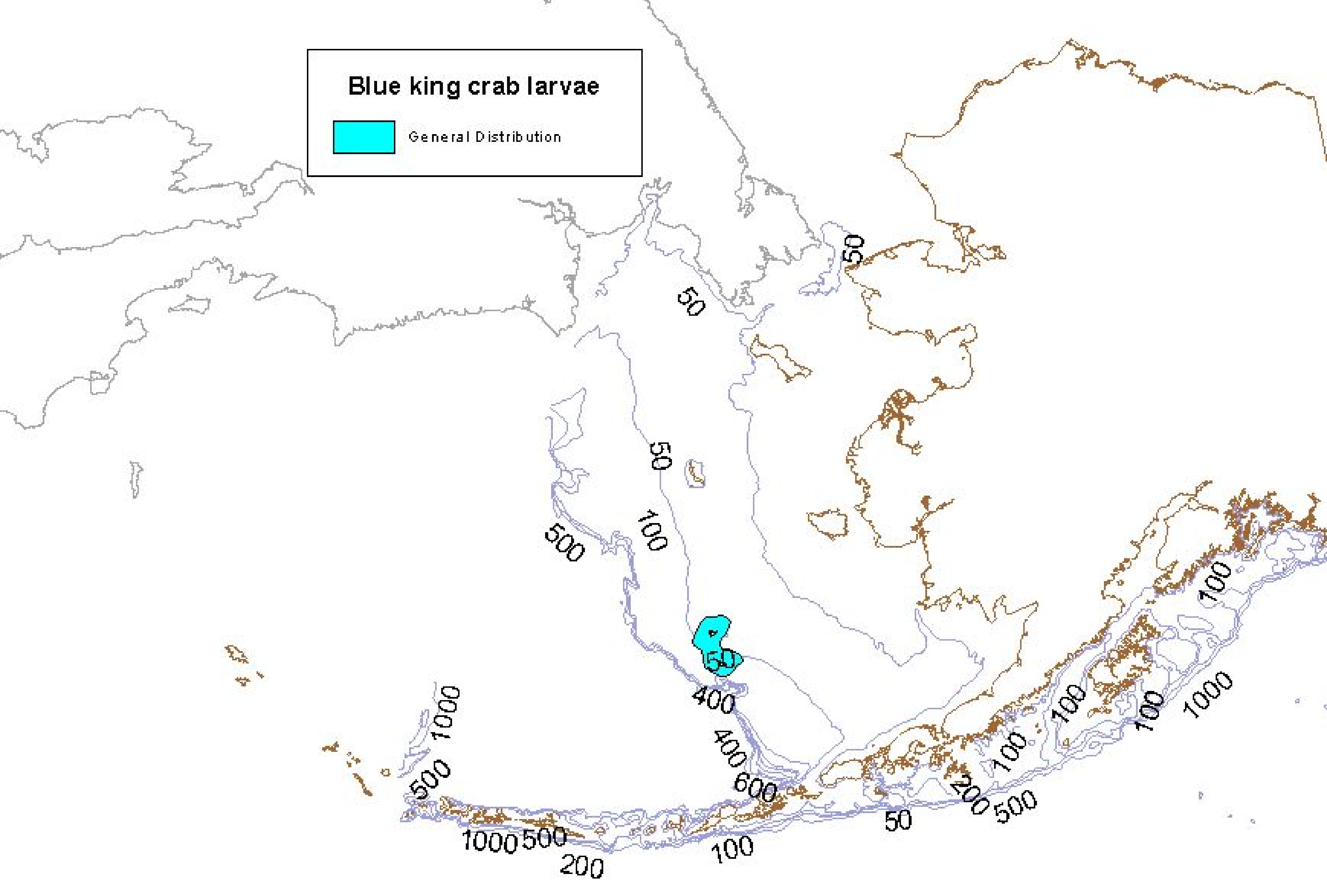

Grooved Tanner crab matures
General Distribution
50
50
50
100
500
50
400
400
600
1000
500
1000
500
200
100
50
100
100
100
100
200
500
1000


Grooved Tanner crab eggs
General Distribution
50
50
50
100
500
50
400
400
600
1000
500
1000
500
200
100
50
200
500
100
100
100
100
1000
100

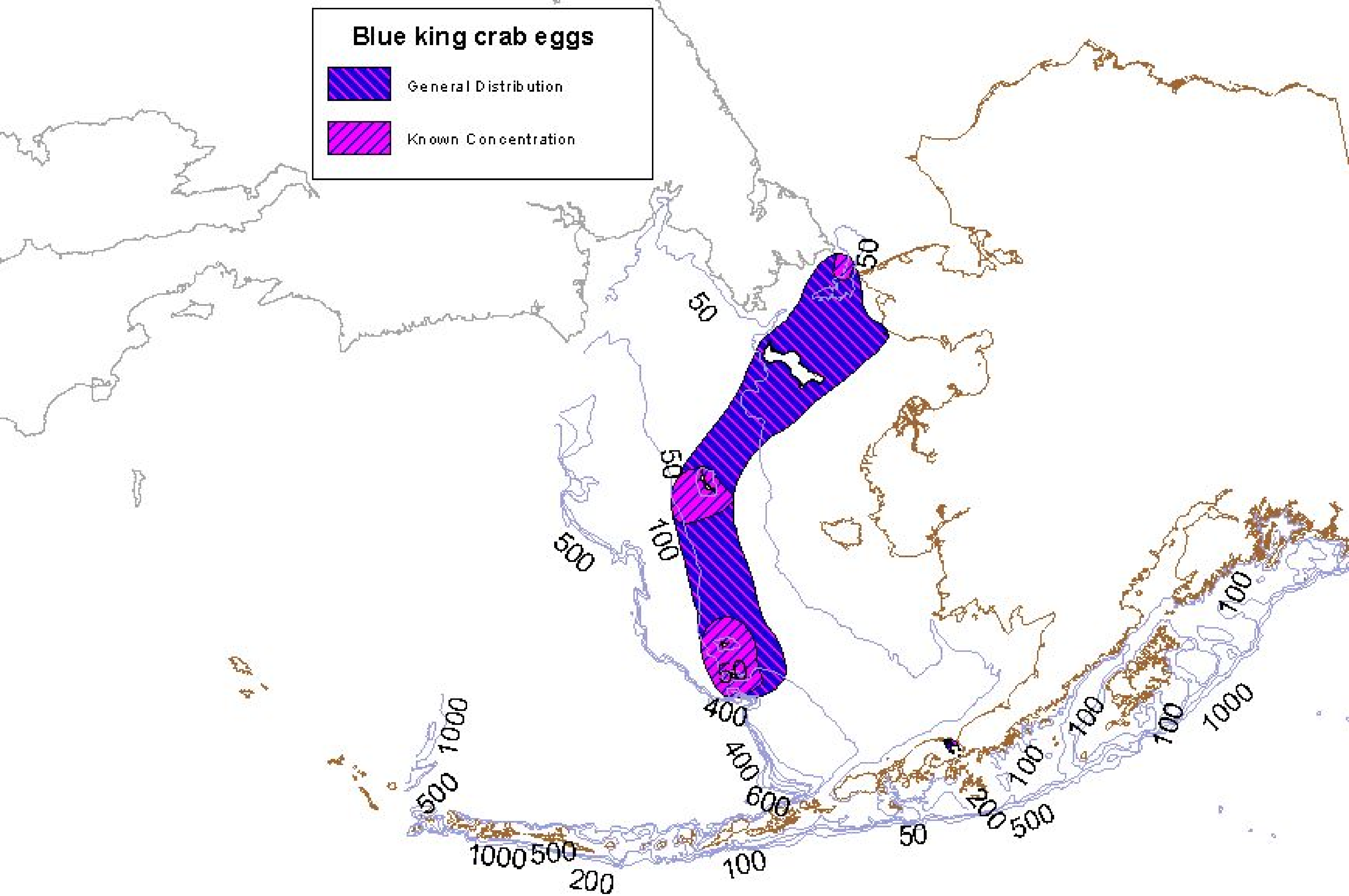

Golden king crab late juveniles and matures
General Distribution
50
50
50
100
500
50
400
400
600
1000
500
500
1000
500
200
100
50
200
500
100
100
100
100
1000

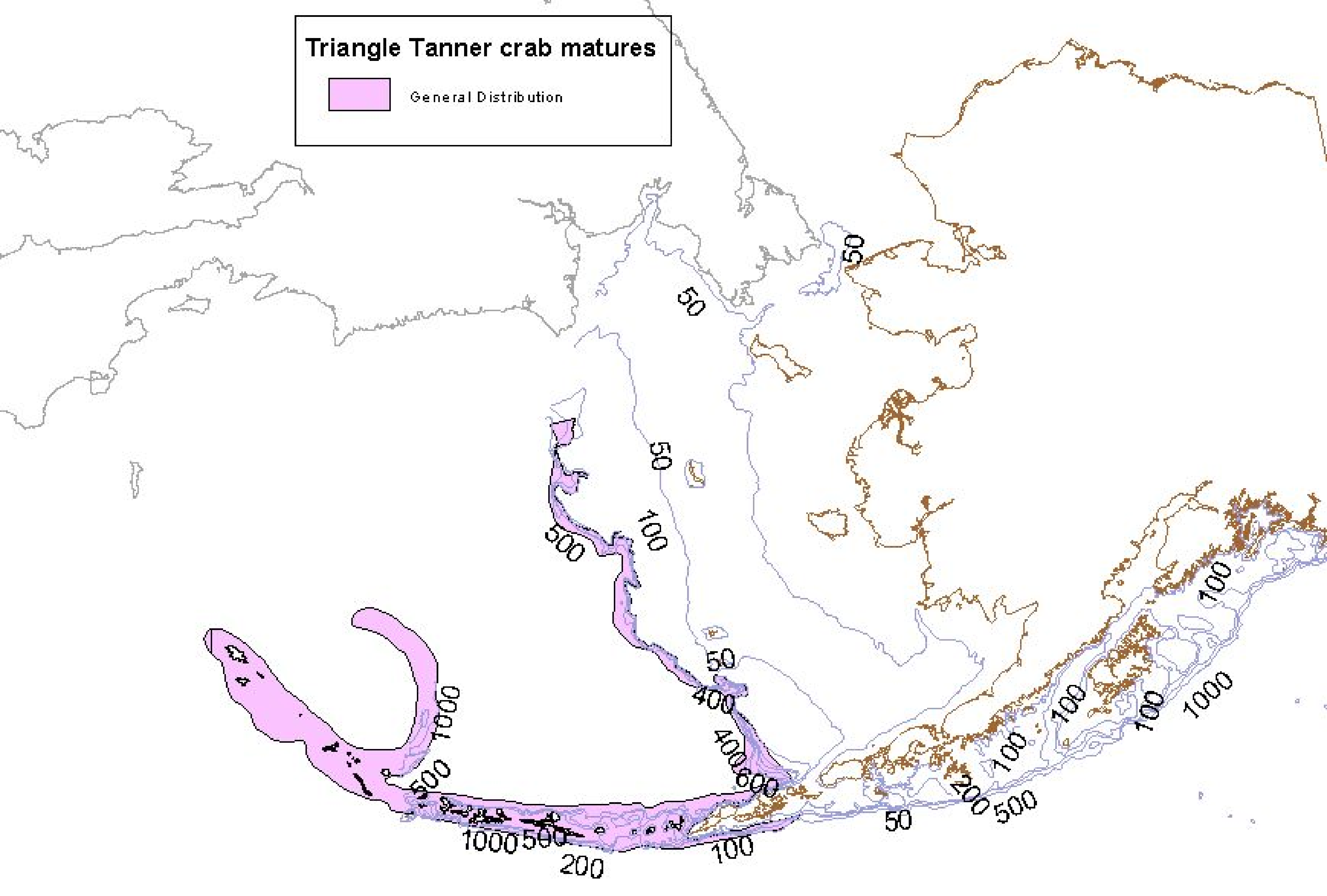

Golden king crab eggs
General Distribution
50
50
50
100
500
50
400
400
600
1000
500
1000
500
200
100
50
200
500
100
100
100
100
1000
100
1000


Blue king crab late juveniles and matures
General Distribution
Known Concentration
50
50
50
50
100
500
400
400
600
1000
500
1000
500
200
100
50
200
500
100
100
100
100
1000
100



Blue king crab larvae
General Distribution
50
50
50
100
500
50
400
400
600
1000
500
1000
500
200
100
50
200
500
100
100
100
100
1000


Blue king crab eggs
General Distribution
Known Concentration
50
50
50
100
500
50
400
400
600
1000
500
1000
500
200
100
50
200
500
100
100
100
1000
100


Triangle Tanner crab matures
General Distribution
50
50
50
100
500
50
400
400
600
1000
500
1000
500
200
100
50
200
500
100
100
100
100
1000

6.4 Alaska Scallops

Summaries and assessments of habitat information for scallops off the coast of Alaska are provided in an Essential Fish Habitat Assessment Report (NPFMC 1997). The Team reviewed Habitat descriptions and life history information was reviewed and the levels of information available for each life stage was determined. The information contained in these summaries along with that contained in data atlases (NOAA 1990) and summaries of survey data (Allen and Smith 1988; Wolotira et al. 1993; Fritz et al. In press) were used to determine the level of knowledge available to identify EFH for each scallop life stage. In evaluating the level of knowledge available, a level 0 was defined as a subset of level 1 as defined by NMFS in the guidelines for determining the level of information on the distribution of a life stage. For scallops, it was determined that information of level 0, 1, and 2 was available. Rationale for using alternative 2 to define EFH (using general distributions of a species life stage even when level 2 and above information was available) appears elsewhere in this EA.

The recommended EFH definition for each scallop life stage is written in the following section and described in Tables 6.7-6.8. The habitats described in the text are located within the general distributions shown on maps for species' life stages with level 1 or 2 information. For those stages with level 1 information, only general distributions within which EFH is located are drawn on maps. For adult scallops (level 2 information), known concentrations are also drawn on the maps within the general distribution, however EFH is defined as the adult's general distribution. No maps are provided for those life stages with level 0 information.

Table 6.7 Levels of essential fish habitat information currently available for Alaska scallops, by life history stage. Juveniles were subdivided into early and late juvenile stages based on survey and fishery selectivity curves.

Species	Eggs	Larvae	Early Juveniles	Late Juveniles	Adults
Weathervane scallops	0a	0a	0a	1	2
Pink scallops	0a	0c	0a	0a	0a
Spiny scallops	0a	0c	0a	0a	0a
Rock scallops	0a	0c	0a	0a	0a

Note: for the larval stages of Pink, Spiny, and Rock scallops information is insufficient to infer general distributions.
0a: Some information on a species' life stage upon which to infer general distribution.
0c: No information on the actual species' life stage and no information on a similar species or adjacent life stages, or where complexity of a species stock structure prohibited inference of general distribution.

References

Allen, M. J., and G. B. Smith. 1988. Atlas and zoogeography of common fishes in the Bering Sea and northeastern Pacific. U.S. Dep. Commerc., NOAA Tech. Rept. NMFS 66, 151 p.

Fritz, L. W., A. Greig, and R. Reuter. Catch-per-unit-effort, length, and depth distributions of major groundfish and bycatch species in the Bering Sea, Aleutian Islands and Gulf of Alaska regions based on research trawl survey data. U.S. Dep. Commerc., NOAA Tech. Memo. NMFS-AFSC. In press.

NOAA. 1990. West coast of North America. Coastal and ocean zones, Strategic assessment: Data atlas. U.S. Dep. Commerc., NOAA, NOS.

NPFMC. 1997. Essential fish habitat assessment report for the scallop fisheries off the coast of Alaska. North Pacific Fishery Management Council, 605 W. 4th Ave., Suite 306, Anchorage, AK 99501.

Wolotira, R. J., Jr., T. M. Sample, S. F. Noel, and C. R. Iten. 1993. Geographic and bathymetric distributions for many commercially important fishes and shellfishes off the west coast of North America, based on research survey and commercial catch data, 1912-1984. U.S. Dep. Commerc., NOAA Tech. Memo. NMFS-AFSC-6, 184 p.

(See table of contents for table)

Table 6.8. Summary of Weathervane scallop habitat and biological associations and reproductive traits.

EFH definition for Alaskan weathervane scallops

Eggs (several days) - Level 0_a
Demersal waters of the inner and middle continental shelf of the Gulf of Alaska and to a lesser extent in the Bering Sea and Aleutian Islands. Eggs are released in the late spring and early summer.

Larvae (2-3 weeks) - Level 0_a
Pelagic waters along the inner, middle, and outer continental shelf of the Gulf of Alaska west of Dixon entrance, extending into the Bering Sea and Aleutian Islands.

Juveniles (to 3 years of age) - Level 1
Areas of clay, mud, sand, and gravel along the mid-continental shelf of the BSAI and GOA.

Adults (3+ years of age) - Level 2
Areas of clay, mud, sand, and gravel along the mid continental shelf of the GOA and BSAI. Areas of concentration are those between the depths of 40-130 m. Scallop beds are generally elongated in the direction of current flow.

EFH definition for Alaskan pink scallops

Eggs (several days) - Level 0_a
Demersal waters of the inner and middle continental shelf of the Gulf of Alaska and to a lesser extent in the Bering Sea and Aleutian Islands. Eggs are released in the winter and early spring.

Larvae (2-3 weeks?) - Level 0_c - No EFH definition determined
Pelagic waters with unknown distribution.

Juveniles (to 2 years of age) - Level 0_a
Soft bottom areas along the inner and mid-continental shelf of the BSAI and GOA.

Adults (2+ years of age) - Level 0_a
Soft bottom areas less than 200 m along the inner, middle, and outer continental shelf of the GOA and BSAI.

EFH definition for Alaskan spiny scallops

Eggs (several days) - Level 0_a
Demersal waters of the inner continental shelf of the Gulf of Alaska and to a lesser extent in the Bering Sea and Aleutian Islands. Eggs are released in the late summer.

Larvae (2-3 weeks?) - Level 0_c - No EFH definition determined
Pelagic waters with unknown distribution.

Juveniles (to 2 years of age) - Level 0_a
Hard bottom areas characterized by strong currents along the inner and middle continental shelf of the GOA.

Adults (2+ years of age) - Level 0_a
Hard bottom areas shallower than 150 m, characterized by strong currents along the inner and middle continental shelf of the GOA.

<u>EFH definition for Alaskan rock scallops</u>

Eggs (several days) - Level 0_a
Demersal waters of the inner continental shelf of the Gulf of Alaska. Eggs are released in the spring and also the autumn months.

Larvae (2-3 weeks?) - Level 0_c - No EFH definition determined
Pelagic waters with unknown distribution.

Juveniles (to 3 years of age) - Level 0_a
Rocky bottoms in shallow waters (0-80m) characterized by strong currents.

Adults (3+ years of age) - Level 0_a
Rocky bottoms in shallow waters (0-80m) characterized by strong currents.

See table of contents for the following maps:

Weathervane scallops (Adults and late juveniles)

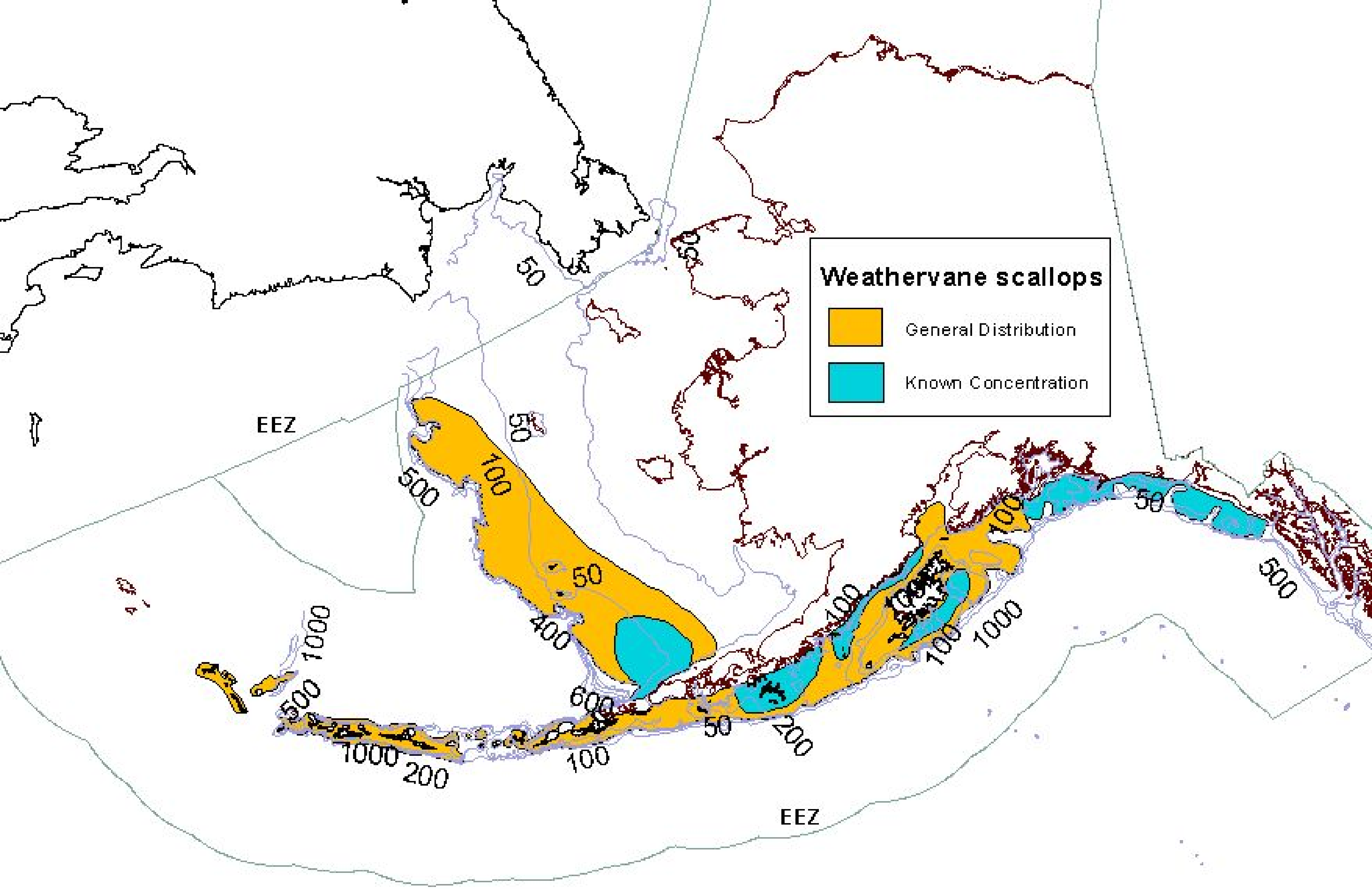
Weathervane scallops (Adults and late juveniles)

	HABITAT ASSOCIATIONS																														
		Location										Substrate								Vegetation		Pelagic Domain					Oceanography					
	Life Stage/Activity	Beach (intertidal)	Inner Shelf (1-50 m)	Middle Shelf (50-100 m)	Outer Shelf (100-200 m)	Upper Slope (200-1000 m)	Lower Slope (>1000m)	Basin (> 3000 m)	Bay/Estuarine	Island pass	Not Known	Mud/Clay/Silt	Sand/Granule	Gravel	Pebble	Cobble	Boulder	Bedrock	Not Applicable	Kelp Forest	Sea Grasses	Near Surface	Pelagic	Semi-demersal/Semi-pelagic	Demersal	Not Known	Upwelling areas	Gyres	Thermo/pycnocline	Fronts	Edges (ice, bathymetric)	Life Stage/Activity
Weathervane scallop	A			X								X	X	X											X							A
	J			X								X	X	X											X							J
	L			X	X														X				X									L
	E		X	X																					X							E

	BIOLOGICAL ATTRIBUTES																								
		Feeding Type						Movements					Social Behavior				Longevity of Life Stage								
	Life Stage/Activity	Carnivore	Herbivore	Omnivore	Planktivore	Detritivore	Not Known	Drift With Ocean Conditions	Reside in Nursery Areas	Alongshore Migrations	Inshore/Offshore Migrations	Not Known	Solitary	Schooling	Shoaling	Not Known	1 Day	1 - 30 Days	1 - 12 Months	1 - 5 Years	5 - 20 Years	20 - 50 Years	> 50 Years	Not Known	Life Stage/Activity
Weathervane scallop	A				X							X				X								X	A
	J				X							X				X								X	J
	L				X			X																X	L
	E							X																X	E

	Reproductive Traits																							
	Age at Maturity				Fertilization/Egg Development					Spawning Behavior						Spawning Season								
	Female		Male																					
	50%	100%	50%	100%	External	Internal	Oviparous	Ovoviviparous	Viviparous	Batch Spawner	Broadcast Spawner	Egg Case Deposition	Nest Builder	Egg/Young Guarder	Egg/Young Bearer	Early Spring	Late Spring	Early Summer	Late Summer	Early Fall	Late Fall	Early Winter	Late Winter	Not Known
Weathervane scallop					X						X						X	X						

Table 1 Summary of Weathervane scallop Habitat and Biological associations and Reproductive traits.



Weathervane scallops
General Distribution
Known Concentration
EEZ
EEZ
50
100
500
50
400
600
1000
500
1000
200
100
50
200
100
100
1000
500

6.5 Alaska Salmon

Because the salmon FMP regulates fisheries in the waters off the entire coast of Alaska and bans net fishing, with exceptions, for salmon off the coast in the EEZ, and also defines management measures for salmon troll fisheries in Southeast Alaska EEZ waters, all water bodies used by anadromous salmon throughout Alaska must be considered for EFH identification. Although much of the salmon troll fishery in SE Alaska occurs within State jurisdictional waters, significant parts of the fishery do occur within the EEZ. As a practical matter, the NPFMC and State of Alaska have effectively implemented this FMP under a joint agreement whereby State fishery regulations also apply within the EEZ. This management deferral by NPFMC to State fishery regulations, however, does not exempt the NPFMC from mandatory requirements to implement EFH provisions of the Magnuson-Stevens Fishery Conservation and Management Act.

Essential Fish Habitat for the salmon fisheries off the coast of Alaska consists of the aquatic habitat, both freshwater and marine, necessary to allow for salmon production needed to support a long-term sustainable salmon fishery and salmon contributions to healthy ecosystems. In addition to providing a sustainable fishery, salmon are important “keystone” species that are fundamental to the integrity and health of their ecosystems. Salmon returning from the sea to spawn transport basic nutrients that support the productivity of stream and lake ecosystems, and the salmon themselves provide essential food for numerous consumer species. Loss of these functions would cause a long-term reduction in ecosystem productivity and reduced population viability for dependent species.

As required by regulations, EFH needs to be defined for different stages of the salmon life history. Six life stages were recognized, based on major differences in distribution and habitat requirements. These were 1) eggs and larvae, 2) juveniles in fresh water, 3) juveniles in the estuary, 4) juveniles before their first winter in the marine environment, 5) immature and maturing adults in the marine environment, and 5) adults in fresh water. Habitat requirements within these periods can differ significantly (e.g., juveniles in freshwater require different habitats for summer rearing, winter rearing, and downstream migration). The six major life stages used in this assessment, however, are defined at a geographic scale appropriate for EFH determinations.

As a first step in identifying and describing EFH for Salmon Fisheries off the Coast of Alaska, the Team summarized the available relevant information on the five species of salmon covered in the NPFMC salmon FMP (attached). Salmon have been studied for many years, and as a result, much is known about their distribution, life histories, and habitat requirements. Relationships between salmon productivity and habitat quantity and quality are generally known, and population bottlenecks have been identified for most life stages. In some cases, quantitative models are available for predicting salmon abundance and production as a function of quantity and quality of habitat. Most of this knowledge, however, is in the form of scientific generalizations that can only be applied if the necessary site-specific habitat information is available.

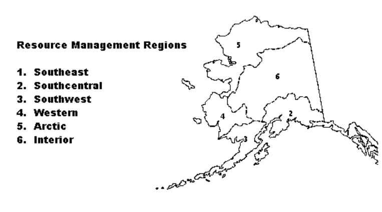


Figure 1. Regional boundaries of the Resource Management Regions established by the Joint Boards of Fisheries and Game.

Because habitat and fish information is lacking for some Alaska watersheds, the Team elected to designate an additional level of information for identifying EFH. A “Level 0" was deemed necessary to accommodate conditions where no systematic sampling has been conducted for the species and life stage in parts of the known geographic range. They may have been caught opportunistically in small numbers during research or other activities. This condition applies to some water bodies in the Western, Arctic, and Interior Regions of Alaska (Figure 1) where limited survey work has been done.

Information levels of EFH assesments currently available for Alaska salmon by regions.

Region I, Southeastern

Species	Eggs and larvae	Juveniles fresh water (fry - smolt)	Juveniles estuarine	Juveniles marine	Adults, immature/ maturing marine	Adults, fresh water
Chinook	1-2	1-2	1-2	1-2	1-2	1-3
Coho	1-3*	2-4*	1-2	1	1	1-3
Pink	1-3	1-3	1-3	1-3	1-3	1-3
Sockeye	1-3	1-4*	1-3	1-2	1-2	1-3
Chum	1-3	1-3	1-3	1-3	1-2	1-3

Region II, Southcentral

Species	Eggs and larvae	Juveniles fresh water (fry - smolt)	Juveniles estuarine	Juveniles marine	Adults, immature/ maturing marine	Adults fresh water
Chinook	1-2	1-3	1	1	1-2	1-3
Coho	1-2	1-2	1-2	1	1-2	1-2
Pink	1-3	1-2	1-2	1-3	1-3	1-3
Sockeye	1-3	1-4	1-2	1	1-2	1-3
Chum	1-3	1-3	1-2	1-3	1-2	1-3

Region III, Southwestern

Species	Eggs and larvae	Juveniles fresh water (fry-smolt)	Juveniles estuarine	Juveniles marine	Adults, immature/ maturing marine	Adults fresh water
Chinook	1-2	1-2	1	1	1-2	1-3
Coho	1-2	1-2	1-2	1	1-2	1-2
Pink	1-2	1-2	1-2	1-2	1-2	1-3
Sockeye	1-3	1-4	1-2	1-2	1-2	1-3
Chum	1-3	1-2	1-2	1-2	1-2	1-3

* Level 3-4 knowledge is available for some stream systems that have been intensively studied, such as the Situk River.

The level of available information for identifying EFH ranges from Level 0 in regions that have not been systematically surveyed to Level 4 in particular watersheds and landscapes that have been studied intensively. Where direct observations are lacking, the distribution of various life stages could sometimes be inferred from correlated data. In this assessment, for example, the distribution of eggs and larvae was inferred from the distribution of spawning adults. Distribution of juveniles in fresh water, however, can not be inferred this way because rearing areas are often different from spawning areas.

For the purpose of identifying EFH, the distribution of salmon in a watershed can be assumed based on access to salt water, with the upstream limits determined by presence of migration blockages, such as waterfalls and stream segments with steep gradient. According to the Alaska Forest Resources and Practices Act (AS 41.17), an "anadromous water body" means the portion of a fresh water body or estuarine area that (A) is cataloged under AS 16.05.870 as important for anadromous fish; or (B) has been determined by ADF&G to contain or exhibit evidence of anadromous fish, in which case the anadromous portion of the stream or waterway extends up to the first point of physical blockage (Table 1). Therefore, if salmon occur in a stream's estuary, the area of stream up to the first point of physical blockage as defined in Table 1 is presumed to be salmon habitat.

Information Sources

A significant body of information exists on the life histories and general distribution of salmon in Alaska. The location of many freshwater water bodies used by salmon are contained in documents organized and maintained by the ADF&G. Alaska Statute 16.05.870 requires ADF&G to specify the various streams that are important for spawning, rearing, or migration of anadromous fishes. This is accomplished through the *Catalog of Waters Important for Spawning, Rearing or Migration of Anadromous Fishes* and the *Atlas to the Catalog of Waters Important for Spawning, Returning or Migration of Anadromous Fishes*. The Catalog lists water bodies documented to be used by anadromous fish. The Atlas shows locations of these waters and the species and life stages that use them. The Catalog and Atlas are divided into six volumes for the six resource management regions established in 1982 by the Joint Boards of Fisheries and Game.

The Catalog and Atlas, however, have significant limitations. The location information and maps are derived from U.S. Geological Survey quadrangles which may be out of date because of changes in channel and coastline configurations. In Southeast Alaska, for example, new streams are colonized by salmon in Glacier Bay as glaciers rapidly recede. Polygons are sometimes used to specify areas with a number of salmon streams that could not be depicted legibly on the maps. Waters within these polygons are often productive for juvenile salmon.

Information levels of EFH assesments currently available for Alaska salmon by regions.

Region IV, Western

Species	Eggs and larvae	Juveniles fresh water (fry - smolt)	Juveniles estuarine	Juveniles marine	Adults, immature/ maturing marine	Adults, fresh water
Chinook	1-2	1	1	1	1-2	1-2
Coho	1-2	1	1	1	1	1-2
Pink	1	1	1	1	1	1
Sockeye	1	1	0a	0a	1-2	1
Chum	1-2	0a	0a	0a	1-2	1-2

Region V, Arctic

Species	Eggs and larvae	Juveniles fresh water (fry - smolt)	Juveniles estuarine	Juveniles marine	Adults, immature/ maturing marine	Adults fresh water
Chinook	1	1	1	1	1	1
Coho	1	1	1	0a	1	1
Pink	1	0a	0a	0a	0a	1
Sockeye	1	1	0a	0a	0a	1
Chum	1	0a	0a	0a	0a	1-2

Region VI, Interior

Species	Eggs and larvae	Juveniles fresh water (fry-smolt)	Juveniles estuarine	Juveniles marine	Adults, immature/ maturing marine	Adults fresh water
Chinook	1	1	1	1	1	1
Coho	1	1	1	1	1	1
Pink	1	0a	0a	1	0a	1
Sockeye	1	1	0a	0a	0a	1
Chum	1-2	1	1	1	1	1-2

Data for the Catalog come from surveys by aircraft, boat, and foot for purposes of managing fish habitat and fisheries, and the upper limit of salmon is not always observed. Upper points specified in the Catalog usually reflect the extent of surveys or known fish usage rather than actual limits of anadromous fish.

In addition, only a limited number of water bodies have actually been surveyed. Virtually all coastal waters in the State provide important habitat for anadromous fish, as do many unsurveyed small- and medium-sized tributaries to known anadromous fish-bearing water bodies in remote parts of the State. Small tributaries, flood channels, intermittent streams and beaver ponds are often used for rearing. Because of their remote location, small size, or ephemeral nature, most of these systems have not been surveyed and are not included in the Catalog or Atlas. Because of their importance in some life stages of some salmon species, these areas fall under the framework of EFH.

A good source of habitat information for Southeast Alaska is a Geographical Information System maintained by the USDA Forest Service. This GIS has a "streams layer" for the Tongass National Forest which classifies streams by fish species present and physical attributes (channel type). For coho salmon, the Forest Service has a model that predicts coho salmon smolt production by channel type. Entire watersheds can be modeled to predict smolt yield. The "streams layer" is continuously updated as new information on location and fish species presence is discovered.

References

Alaska Department of Fish and Game. 1997. An atlas to the catalog of waters important for spawning, rearing, or migration of anadromous fishes. ADF&G, Habitat and Restoration Division, 333 Raspberry Road, Anchorage, AK. 99518-1599 .

Alaska Department of Fish and Game (ADF&G). 1986. Alaska habitat management guide; guidelines for the protection of fish and their habitat. ADF&G, Habitat Division, 142 p. Juneau, AK 99801

Groot, C., and L. Margolis. (eds.) 1991. Pacific salmon life histories. Univ. British Columbia Press.

Gustafson, R. G., T. C. Wainwright, G. A. Winans, F. W. Waknitz, L. T. Parker, and R.S. Waples. 1997. Status review of sockeye salmon from Washington and Oregon. NOAA Tech. Memo. NMFS-NWFSC-33. NMFS, 2725 Montlake Blvd. E., Seattle, WA 98112-2097

Halupka, K.C., M. F. Wilson, M. D. Bryant, F. H. Everest and A. J. Gharrett. in press. Intraspecific diversity of Pacific salmon in Southeast Alaska. Forestry Sci. Lab., Pacific Northwest Research Station, USDA. 2770 Sherwood Lane, Suite 2A Juneau, AK 99801-8545

Hard, J. J., R. G. Kope, W. S. Grant, F. W. Waknitz, L. T. Parker, and R. S. Waples. 1996. Status review of pink salmon from Washington, Oregon, and California. NOAA Tech. Memo. NMFS-NWFSC-25. NMFS, 2725 Montlake Blvd. E., Seattle, WA 98112-2097

Johnson, O. W., W. S. Grant, R. G. Kope, K. Neely, F. W. Waknitz, and R. S. Waples 1997. Status review of chum salmon from Washington, Oregon, and California. NOAA Tech. Memo. NMFS-NWFSC-32. NMFS, 2725 Montlake Blvd. E., Seattle, WA 98112-2097.

Myers, K.W., K. Y. Aydin, R. V. Walker, S. Fowler, and M. L. Dalhberg. 1996. Known ocean ranges of stocks of Pacific salmon and steelhead as shown by tagging experiments, 1956-1995. (NPAFC Doc. 192.) FRI-UW-9614. Univ. Wash., Fisheries Research Institute, Box 357980, Seattle, WA 98195-7980.

USDA Forest Service, Geographic Information System, Streams Layer. U.S. Forest Service, Juneau, AK 99801.

Weitkamp, L. A., T. W. Wainwright, G. J. Bryant, G. B. Miller, D. J. Teel, R. G. Kope, and R. S. Waples. 1995. Status review of coho salmon from Washington, Oregon, and California. NOAA Tech. Memo. NMFS-NWFSC-24. NMFS, 2725 Montlake Blvd. E., Seattle, WA 98112-2097

Wertheimer, W.C. 1996. The status of Alaska salmon. Pages 179-197 *In* J. D. Stroder, P. A. Bisson, and R. J. Naiman (eds.). Pacific salmon and their ecosystems: status and future options. Symposium Proc., Seattle, WA., Jan. 10-12, 1994. Chapman Hall, NY.

Table 6.9 Criteria for determining the upstream limit of salmon in a stream system. The area downstream of the lowermost migration barrier on a stream is presumed to be salmon habitat where ADF&G has determined that the stream or estuary contains the species. This table was developed by the Department of Fish and Game and Department of Natural Resources as a revision to the Alaska Forest Resources and Practices Act (AS 41.17.950).

Criterion	Species				
	Chinook	Coho	Sockeye	Chum	Pink
Max Fall Height. A blockage may be presumed if fall height exceeds:	3.3 m	3.3 m	3.0 m	1.2 m with deep jump pool; 0.9 m without pool	
Pool depth. A blockage may be presumed if the unobstructed water column depth within the pool is less than:	1.25 times fall height, except that there is no minimum pool depth for falls <1.2 m for coho and <0.6 m for other species.				
Steep channel. A blockage may be presumed at the upper end of the reach if channel steepness exceeds the following without resting places for fish:	>70 m @ 12% gradient >30 m @ 16% gradient >15 m @ 20% gradient >8 m @ 24% gradient			>30 m @ 9% gradient	

SUMMARY OF TECHNICAL TEAM RECOMMENDATIONS

Salmon EFH is the aquatic habitat, both freshwater and marine, necessary to allow for salmon production needed to support a long-term sustainable salmon fishery and salmon contributions to healthy ecosystems.

Freshwater EFH for the salmon fisheries in Alaska includes all streams, lakes, ponds, wetlands, and other water bodies currently or historically accessible to salmon in the State.
This represents a vast array of diverse aquatic habitats over an extremely large geographic area. Alaska contains over 3,000 rivers and has over 3 million lakes > 8 ha. Over 15,000 water bodies containing anadromous salmonids identified in the State represent only part of the salmon EFH in Alaska because many likely habitats have not been surveyed. In addition to current and historically accessible waters used by Alaska salmon, other potential spawning and rearing habitats exist beyond the limits of upstream migration due to barrier falls or steep-gradient rapids. Salmon access to existing or potential habitats can change over time due to many factors, including glacial advance or recession, post-glacial rebound, and tectonic subsidence or uplifting of streams in earthquakes.

Marine EFH for the salmon fisheries in Alaska include all estuarine and marine areas utilized by Pacific salmon of Alaska origin, extending from the influence of tidewater and tidally submerged habitats to the limits of the U.S. EEZ.

This habitat includes waters of the Continental Shelf, which extends to about 30-100 km offshore from Dixon Entrance to Kodiak Island, then becomes more narrow along the Pacific Ocean side of the Alaska Peninsula and Aleutian Islands chain. In Bering Sea areas of Southwest and Western Alaska and in Chukchi and Beaufort Seas areas of Northwest and Northern Alaska, the Continental Shelf becomes much wider. In the deeper waters of the Continental Slope and ocean basin, salmon only occupy the upper water column, generally from the surface to a depth of about 50 m. Chinook and chum salmon, however, use deeper layers, generally to about 300 m, and on occasion to 500 m.

Marine EFH for salmon off Alaska therefore, is the subset of habitat that occurs within the 320 km EEZ boundary of the United States in the Gulf of Alaska, Bering Sea, Chukchi, and Beaufort Seas to a depth of 500 m. The range of Alaska salmon extends far beyond this definition of EFH into oceanic waters beyond the EEZ since the documented range of Alaska salmon extends from 42° N latitude north to the Arctic Ocean and to 160° E longitude. Foreign waters (i.e., off British Columbia in the Gulf of Alaska and off Russia in the Bering Sea) and international waters are not included in this salmon EFH. It is estimated this definition of marine waters EFH for Alaska salmon includes perhaps only 60% of the total known oceanic range for these fishes. This marine EFH for Alaska salmon and associated fisheries described above is also EFH for the Pacific coast salmon fishery for those salmon stocks of Pacific Northwest origin that migrate through Canadian waters into the Alaska EFH zone.

Several stocks of Pacific Northwest salmon currently listed as threatened or endangered under the Endangered Species Act (ESA) migrate into the marine waters EFH off Alaska. Many of these and other West Coast stocks initially migrate northward along the coastline as juveniles, usually on the Continental Shelf. As growth occurs and these stocks move into Alaska waters many begin to move seaward into more open oceanic environments. These same stocks may become mixed across broad oceanic areas with Alaska-origin salmon.

The technical team recommends that all habitats within the jurisdictional boundaries of Alaska that are accessible to salmon be identified as EFH for salmon. All of this habitat contributes to production at some level. Although production from individual habitat areas may be small, collectively even small contributions help to sustain salmon fisheries at current levels. Fisheries for coho and pink salmon, for example, depend on the cumulative production from thousands of small streams that are widely distributed across coastal Alaska. To maintain the present healthy status of the ecosystem and fisheries, it must be recognized that any incremental loss of available habitat will result in less-healthy stocks with reduced fishery potential. Policies that accept reductions in Alaska salmon EFH by designating less-essential subsets of existing habitats could cause unacceptable reductions in salmon contributions to fisheries and ecosystems. In the case of threatened or endangered Pacific Northwest stocks reductions in marine waters EFH off Alaska could jeopardize ESA recovery plans. It is appropriate, therefore, that all salmon habitats in fresh waters within Alaska and marine waters off Alaska be identified as EFH.

In the marine environment, Pacific salmon range throughout the Gulf of Alaska, North Pacific Ocean, and Bering Sea. Virtually all marine waters adjacent to Alaska, from nearshore and coastal areas to the limits of the U.S. EEZ, are utilized by salmon. Large-scale research programs, such as GLOBEC and OCC, currently are addressing the concern that ocean carrying capacity for salmon is limited, and density-dependent restrictions on growth or survival may be occurring at current levels of abundance. If density-dependent interactions are already evident, any reduction or degradation of marine habitats of salmon will result in incremental loss in productivity.

Thus at this time, all existing marine habitat is essential to maintain current levels of abundance and productivity of salmon in Alaska and to help restore depleted Pacific Northwest stocks that migrate into Alaska waters. There is, substantial rationale to justify such an inclusive definition of EFH. Even when habitats remain stable, salmon populations may fluctuate significantly due to factors such as weather, climate, and changes in predator or prey abundance. Salmon use a broader range of freshwater habitat during periods of high abundance. Habitat productivity also varies along with natural long-term disturbance regimes, so that a particular watershed may have low productivity after an event such as a major flood, followed by a period of higher, more stable productivity. Locations of salmon concentrations in freshwater, estuarine, and marine habitats may change unpredictably, so that current areas of known concentration would not adequately cover required habitat. Regime shifts in ocean conditions can also cyclically affect the presence and abundance of food or predators and as a result salmon distribution and survival.

There is a growing body of evidence that such a regime shift is currently underway indicated by further significant declines in marine survivals of salmon in the Pacific Northwest and British Columbia. Now, these same reduced marine survivals are also affecting Alaska salmon stocks where a dramatic 45% reduction in the commercial harvest has occurred over the last two years, from 218 million in 1995 to 121 million in 1997. Designating only that habitat with current high abundance or productivity as EFH ignores the implications of such short- and long-term cycles. The broad range and diversity of salmon habitats must be conserved to provide for periods of abundance, as well as to avoid severely reduced production during poor years.

The recommended definition of salmon EFH is most consistent with existing Federal and State laws and policies that protect anadromous fish and their habitat, such as Alaska Statute Title 16, the Alaska Forest Resources and Practices Act, the National Forest Management Act, the Tongass Land Management Plan, the Clean Water Act, and the Coastal Zone Management Act. These laws and policies conserve anadromous fish habitat and do not exempt portions of it based on relative productivity.

Even with the inclusive definition of EFH recommended here, significant portions of salmon habitat would not be designated as EFH because they are outside U.S. jurisdiction. Examples of specific habitat areas that are not considered EFH for Alaska salmon are l) Canadian parts of the transboundary rivers, including the upper Yukon River where major chinook and chum salmon production contributes to Alaska fisheries; and 2) international waters outside the EEZ.

Based on the foregoing information and attached descriptions of essential habitat for chinook, coho, pink, chum, and sockeye salmon, the following specific definitions of EFH are proposed, by species and life stage, for the salmon fisheries in Alaska. Maps showing the extent of recommended EFH are provided only for immature and maturing adult salmon in marine habitats. These maps show the general distribution and areas of known concentration. Areas of known concentration of maturing and adult salmon in the marine environment have been identified for some species based on bycatch in fisheries, such as chinook, chum, and sockeye salmon bycatch in the Bering Sea trawl fishery. These known concentrations, however, reflect points where fish become concentrated on migration routes from the open ocean to fresh water (e.g., Unimak Pass); they do not indicate exceptional habitats necessary for rearing and maturing. In addition, NMFS research has identified the area off Prince William Sound to Kodiak Island as a possible area of concentration of chum salmon in summer. Current knowledge of salmon distribution in the ocean is inadequate to identify other concentrations or areas of exceptional production.

The concept of "areas of known concentration" as used for marine EFH applies differently to salmon in fresh water. In fresh water, concentrations of salmon reflect locations of specific habitats for spawning, rearing, and migration that are patchily distributed on a finer scale (at the reach level) within watersheds. Freshwater habitat is very heterogeneous, and at a local level, depends on geomorphic, vegetative, hydrologic, and other factors, and also varies along the "river continuum" from headwaters to river mouth. Therefore, the distribution of habitat and fish within specific watersheds must be considered on a case-by-case basis to identify areas of concentration. Such areas of concentration--usually of spawning adult salmon--have been identified for a small number of specific river systems that have been intensively surveyed, primarily in Southeast (Region I), Southcentral (Region II); and Southwestern (Region III) Alaska. By radio tagging, for example, NMFS research has identified areas of concentrated chinook and sockeye salmon spawning in the Taku River, which could be considered areas of known concentration. For the vast majority of watersheds, however, information is insufficient to identify areas of known concentration, particularly for juvenile salmon.

The general distribution of salmon in fresh water includes virtually all the coastal streams to about 70° N latitude. Maps of documented salmon occurrence in fresh water (representing only a subset of salmon EFH) are available in the ADF&G stream Atlas. These maps show presence/absence of anadromous fish in areas that have been surveyed, but do not show fish densities, and therefore, they do not depict areas of known concentration. It would be possible to delineate areas of known concentration of salmon in some watersheds. First, one would identify watersheds with sufficient information and then delineate areas of known concentration within the watersheds. This would only be possible for a small number of watersheds, and generally only for adult salmon. It could be done for juvenile salmon in a few watersheds.

See table of contents for the following tables:

Habitat Associations

Reproductive Traits

Known Life History Traits

<u>EFH Definition for Chinook Salmon</u>

Eggs and larvae: Level 1 and Level 2

Those portions of fresh waters in Alaska within the bounds of ordinary high water where chinook salmon currently or historically occur, that are accessible to adult chinook salmon (or could be cost-effectively made accessible), and that have bottom substrate, water quality, and seasonal flow adequate for the incubation and development of chinook salmon eggs and larvae. Impaired areas with potential for cost-effective restoration are also EFH for chinook salmon. Eggs and larvae require more than 200 days over the period from July to May for incubation in intragravel flows.

Juveniles (freshwater): Levels 1 - 3

Those portions of fresh waters in Alaska within the bounds of ordinary high water where chinook salmon currently or historically occur, that are accessible to juvenile chinook salmon (or could be cost-effectively made accessible), and that provide adequate water quality and productivity conditions for seasonal or year-round rearing or migration for juvenile chinook salmon. Impaired areas with potential for cost-effective restoration are also EFH for chinook salmon. Juvenile chinook salmon require year-round rearing habitat and also migration habitat from April to September to provide access to the sea.

Juveniles (estuarine): Level 1 and Level 2

The salinity transition zone (ecotone) and contiguous intertidal and nearshore habitats below mean higher high tide in Alaska where chinook salmon currently or historically occur. Chinook salmon smolts and post-smolt juveniles may be present in these estuarine habitats from April through September.

Juveniles (marine): Level 1 and Level 2

Marine waters from Dixon Entrance to the Bering Straits, extending from the intertidal to the limits of the U.S. EEZ. Juvenile chinook salmon are present in this habitat from April until annulus formation in January/February of their first winter at sea.

Immature and maturing adults (marine): Level 1 and Level 2

Marine waters below mean higher high tide from Dixon Entrance to the Bering Straits, extending from the intertidal to the limits of the U.S. EEZ. Immature chinook salmon use this marine habitat year-round. Maturing fish generally are considered to be in their ultimate year of life, and thus utilize the habitat from January until September, by which time they have entered freshwater or moved out of the marine EFH in Alaska.

Adults (freshwater): Levels 1 - 3

Those portions of fresh waters in Alaska within the bounds of ordinary high water where chinook salmon currently or historically occur, that are accessible to adult chinook salmon (or could be cost-effectively made accessible), and that provide suitable water quality, migration access, holding areas, and spawning substrates and flow regimes. Impaired areas with potential for cost-effective restoration are also EFH for chinook salmon. Adult chinook salmon utilize such freshwater habitats in Alaska from April through September.

EFH Definition for Coho Salmon

Eggs and Larvae (Fresh water): Levels 1 - 3

Those portions of fresh waters in Alaska within the bounds of ordinary high water where coho salmon currently or historically occur, that are accessible to adult coho salmon (or could be cost-effectively made accessible), and that have substrate, water quality, and seasonal flow adequate for the incubation and development of coho salmon eggs and larvae. Impaired areas with potential for cost-effective restoration are also EFH for coho salmon. Eggs and larvae require >150 days of incubation (generally over the period of October to May). Preferred substrate is gravel containing <15% fine sediment (<2 mm diameter).

Juveniles (Fresh water): Levels 1 - 4

Those portions of fresh waters in Alaska within the bounds of ordinary high water where coho salmon currently or historically occur, that are accessible to juvenile coho salmon (or could be cost-effectively made accessible), and that provide adequate water quality and productivity conditions for seasonal or year-round rearing or migration for juvenile coho salmon. Impaired areas with potential for cost-effective restoration are also EFH for coho salmon. Juvenile coho salmon require year-round rearing habitat and also migration habitat from April to November to provide access to and from the estuary.

Juveniles (Estuary): Level 1 and Level 2

Those portions of the salinity transition zone (ecotone) and contiguous intertidal and nearshore habitat below mean higher high tide in Alaska where coho salmon currently or historically occur. Smolts may be present May to August; non-smolts rear in spring and summer.

Juveniles (Marine): Level 0_a and Level 1

Marine waters below mean higher high tide from Dixon Entrance to the Bering Straits, extending from the intertidal to the limits of the continental shelf and to a depth of 50 meters. Juveniles occupy this area from June to September.

Immature and Maturing Adults (Marine): Level 1 and Level 2

Marine waters below mean higher high tide from Dixon Entrance to the Bering Straits, extending from the intertidal to the limits of the U.S. EEZ and to a depth of 200 meters. Immature coho salmon use this marine habitat year-round. Immature fish generally enter this habitat in late summer and maturing coho salmon return to fresh water to spawn the following late summer or fall.

Adults (Fresh water): Levels 1 - 3

Those portions of fresh waters in Alaska within the bounds of ordinary high water where coho salmon currently or historically occur, that are accessible to adult coho salmon (or could be cost-effectively made accessible), and that provide suitable water quality, migration access, holding areas, and spawning substrates and flow regimes. Impaired areas with potential for cost-effective restoration are also EFH for coho salmon. Adult coho may be present in fresh water from July to December.

EFH Definition for Pink Salmon

Egg/Larvae (Fresh water): Levels 1 - 3
Those portions of fresh waters and the intertidal portion of streams in Alaska within the bounds of ordinary high water where pink salmon currently or historically occur, that are accessible to adult pink salmon (or could be cost-effectively made accessible), and that have substrate, water quality, and seasonal flow adequate for the incubation and development of pink salmon eggs and larvae. Impaired areas with potential for cost-effective restoration are also EFH for pink salmon. Eggs and larvae require approximately 225 days of incubation over the period of late summer to early spring. Preferred substrate is medium to course gravel containing <15% fine sediment (<2 mm diameter), 15-50 cm in depth.

Juveniles (Fresh water): Level 0_a and Levels 1 - 3
Those portions of fresh waters in Alaska within the bounds of ordinary high water where pink salmon currently or historically occur, that are accessible to pink salmon (or could be cost-effectively made accessible), and that provide adequate water quality conditions for seasonal migration for pink salmon fry. Impaired areas with potential for cost-effective restoration are also EFH for pink salmon. Migrating pink salmon fry are in stream systems during spring, generally migrating in darkness in the upper water column. Fry leave streams in 1-15 days, and the duration of migration from a stream may last 2 months.

Juveniles (Estuary): Level 0_a and Levels 1 - 3
Those portions of the salinity transition zone (ecotone) and contiguous intertidal and nearshore habitats below mean higher high tide in Alaska where pink salmon currently or historically occur. Pink salmon juveniles may be present from late April through June.

Juveniles (Marine): Level 0_a and Levels 1 - 3
Coastal waters all along the continental shelf throughout Alaska from mid-summer until December; then moving further off shelf into more pelagic oceanic areas, generally in the upper 50 m of the water column.

Immature and Maturing Adults (Marine): Level 0_a and Levels 1 - 3
Marine waters below mean higher high tide from Dixon Entrance to the Bering Straits, extending from the intertidal to the limits of the U.S. EEZ and to a depth of 200 meters. Pink salmon are present from fall through the mid-summer in pelagic waters.

Adults (Fresh water): Levels 1 - 3
Those portions of fresh waters and intertidal areas of streams within the bounds of ordinary high water in Alaska where pink salmon currently or historically occur, that are accessible to adult pink salmon (or could be cost-effectively made accessible), and that provide suitable water quality, migration access, holding areas, and spawning substrates and flow regimes. Impaired areas with potential for cost-effective restoration are also EFH for pink salmon. Adult pink salmon may be present in fresh water and the intertidal areas of streams from June through September.

EFH Definition for Chum Salmon

Eggs and Larvae (Fresh water): Levels 1 - 3
Those portions of fresh waters and the intertidal portion of streams in Alaska within the bounds of ordinary high water where chum salmon currently or historically occur, that are accessible to adult chum salmon (or could be cost-effectively made accessible), and that have substrate, water quality, and seasonal flow (including upwelling ground water) adequate for the incubation and development of chum salmon eggs and larvae. Impaired areas with potential for cost-effective restoration are also EFH for chum salmon. Eggs and larvae incubate from late summer to early spring. Preferred substrate is medium to course gravel containing <15% fine sediment (<2 mm diameter); finer substrates can be used in upwelling areas of streams and sloughs.

Juveniles (Fresh water): Level 0_a and Levels 1 - 3
Those portions of fresh waters in Alaska within the bounds of ordinary high water where chum salmon currently or historically occur, that are accessible to chum salmon (or could be cost-effectively made accessible), and that provide adequate water quality conditions for seasonal migration for chum salmon fry. Impaired areas with potential for cost-effective restoration are also EFH for chum salmon. Migrating chum salmon fry are in stream systems during spring, generally migrating in darkness in the upper water column.

Juvenile Stages (Estuarine): Level 0_a and Levels 1 - 3
Those portions of the salinity transition zone (ecotone) and contiguous intertidal and nearshore habitats below mean higher high tide in Alaska where chum salmon currently or historically occur. Chum salmon juveniles may be present from late April through June.

Juvenile Stages (Marine): Level 0_a and Levels 1 - 3
Those areas of ocean in the State of Alaska and the U.S. EEZ over the continental shelf between 0 and 50 meters in depth.

Immature and Maturing Adults (Marine): Level 0_a and Levels 1 - 3
Marine waters below mean higher high tide from Dixon Entrance to the Bering Straits, extending from the intertidal to the limits of the U.S. EEZ and to a depth of 200 meters. Chum salmon are present year round in pelagic waters.

Adults (Freshwater): Levels 1 - 3
Those portions of fresh waters and intertidal areas of streams within the bounds of ordinary high water in Alaska where chum salmon currently or historically occur, that are accessible to adult chum salmon (or could be cost-effectively made accessible), and that provide suitable water quality, migration access, holding areas, and spawning substrates and flow regimes. Impaired areas with potential for cost-effective restoration are also EFH for chum salmon. Adult chum salmon may be present in fresh water and intertidal areas of streams from June through January.

EFH Recommendation for Sockeye Salmon

Egg/Larvae (Fresh water): Levels 1 - 3
Those portions of fresh waters in Alaska within the bounds of ordinary high water where sockeye salmon currently or historically occur, that are accessible to adult sockeye salmon (or could be cost-effectively made accessible), and that have substrate, water quality, and seasonal flow (including upwelling ground water) adequate for the incubation and development of sockeye salmon eggs and larvae. Impaired areas with potential for cost-effective restoration are also EFH for sockeye salmon. Sockeye often spawn in lake substrates, as well as in streams. Eggs and larvae are in these habitats from July through May. Preferred substrate is medium to course gravel containing <15% fine sediment (<2 mm diam.); finer substrates can be used in upwelling areas of streams and sloughs.

Juveniles (Fresh water): Levels 1 - 4
Those portions of fresh waters in Alaska within the bounds of ordinary high water where sockeye salmon currently or historically occur, that are accessible to juvenile sockeye salmon (or could be cost-effectively made accessible), and that provide adequate water quality and productivity conditions for seasonal rearing and migration for juvenile sockeye salmon. Impaired areas with potential for cost-effective restoration are also EFH for sockeye salmon. Juvenile sockeye salmon require year-round rearing habitat and also migration habitat from April to November to provide access to the estuary. Fry generally migrate downstream to a lake or, in systems lacking a freshwater lake, to estuarine and riverine rearing areas. Migration of fry and smolts is generally in spring and summer.

Juveniles (Estuary): Level 0_a, Level 1 and Level 2
Those portions of the salinity transition zone (ecotone) and contiguous intertidal and nearshore habitats below mean higher high tide in Alaska where sockeye salmon currently or historically occur. Under-yearling, yearling, and older smolts occupy estuaries from March through early August.

Juveniles (Marine): Level 0_a, Level 1 and Level 2
Coastal waters all along the continental shelf throughout Alaska and the U.S. EEZ from mid-summer until December; generally in the upper 50 m of the water column.,

Immature and Maturing Adults (Marine): Level 0_a, Level 1 and Level 2
Marine waters below mean higher high tide from Dixon Entrance to the Bering Straits, extending from the intertidal to the limits of the U.S. EEZ and to a depth of 200 meters. Sockeye salmon are present year round in pelagic waters. Ocean residence is 1-3 years.

Adults (Fresh water): Levels 1- 3
Those portions of fresh waters and upper intertidal areas of streams within the bounds of ordinary high water in Alaska where sockeye salmon currently or historically occur, that are accessible to adult sockeye salmon (or could be cost-effectively made accessible), and that provide suitable water quality, migration access, holding areas, and spawning substrates and flow regimes. Impaired areas with potential for cost-effective restoration are also EFH for sockeye salmon. Adult sockeye salmon may be present in fresh water from June through September, and sockeye often spawn in lake substrates, as well as in streams.

See table of contents for the following maps:

General Distribution of Eggs and Larvae, Freshwater Juvenile and Adult Chinook, Chum, Coho, Pink and Sockeye Salmon

General Distribution of Eggs and Larvae, Freshwater Juvenile and Adult Chinook, Chum, Coho, Pink and Sockeye Salmon (Southeast Alaska and GOA)

General Distribution of Eggs and Larvae, Freshwater Juvenile and Adult Chinook, Chum, Coho, Pink and Sockeye Salmon (Western Alaska and BSAI)

General Distribution of Eggs and Larvae, Freshwater Juvenile and Adult Chinook, Chum, Coho, Pink and Sockeye Salmon (Western Alaska and Bering Sea)

General Distribution of Eggs and Larvae, Freshwater Juvenile and Adult Chinook, Chum, Coho, Pink and Sockeye Salmon (Alaska)

General Distribution of Eggs and Larvae, Freshwater Juvenile and Adult Chinook, Chum, Coho, Pink and Sockeye Salmon (Northern Alaska and Arctic Ocean)

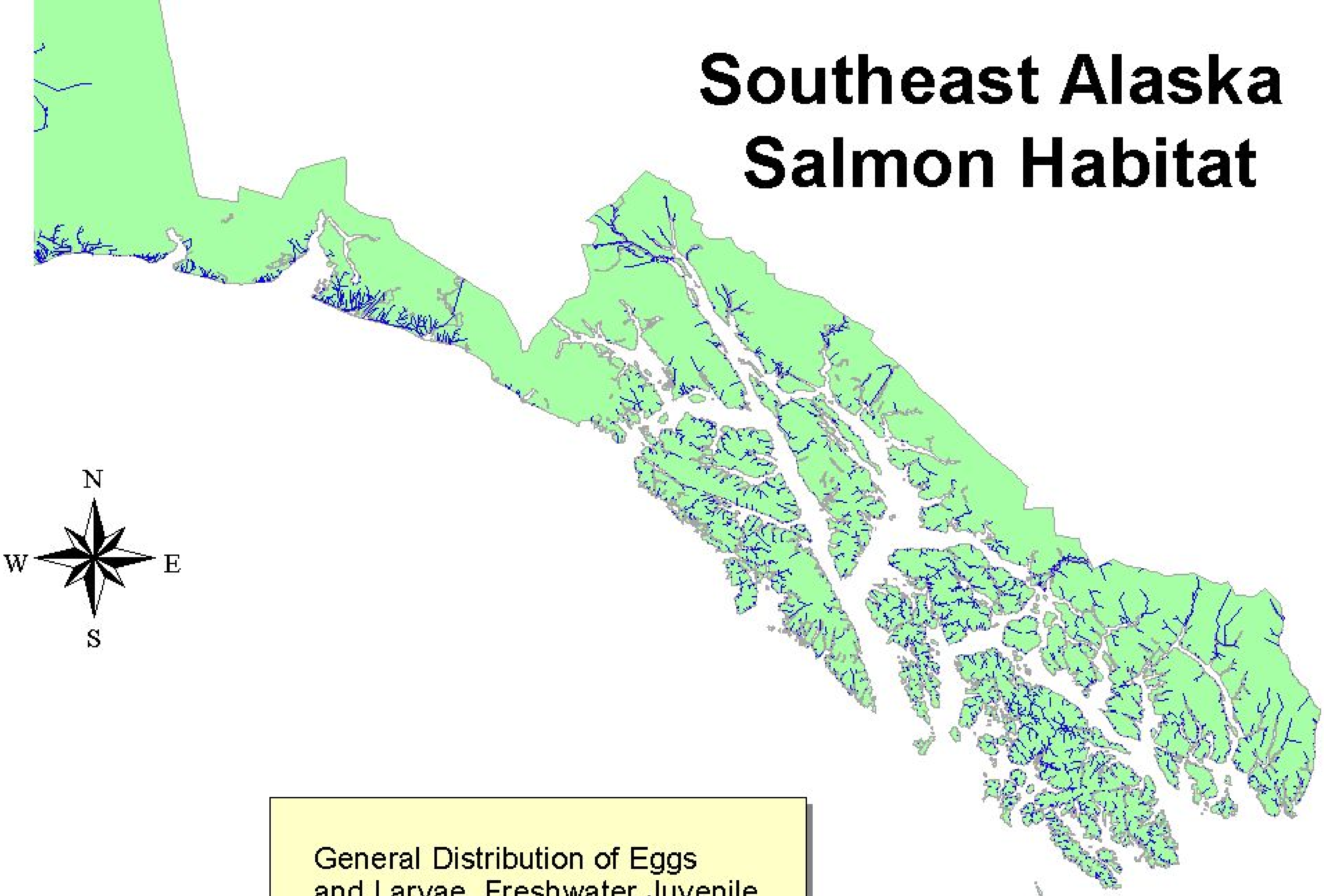
		HABITAT ASSOCIATIONS																																											
		Habitats					Benthic Domain										Structure, Substrate, and Vegetation																					Pelagic Domain				Oceanography		
							Shelf			Slope			Canyon				Structure										Substrate								Vegetation										
	Life Stage/Activity	Fresh Water	Estuarine	Nearshore (50-200m)	Offshore (>200m)	Vertical Depth (m)	Intertidal	Subtidal (<30m)	Intermediate (30-100m [Break])	Upper (Break-500 m)	Intermediate (500-1000m)	Lower (>1000m)	Head (<100m)	Upper and Middle (100-500 m)	Lower (>500m)	Not Known	Bars	Banks	Sinks	Slumps/Rockfalls/Debris Field	Channels	Ledges	Pinnacles	Reefs	Vertical Walls	Artificial	Organic Debris	Mud/Clay/Silt	Sand/Granule	Gravel	Pebble	Cobble	Boulder	Bedrock	Estuarine, eg. Algal Cover	Kelp Forest	Marine, eg. Sea Grasses	Not Known	Near Surface	Midwaters	Near Bottom	Not Known	Temperature (Celsius)	Salinity (ppt)	Life Stage/Activity
Chinook Salmon	EL	M																												M	M														EL
	JF	M																																					M	M	M				JF
	JE		M	M																																				M	M				JE
	JM		M	M	M	<200 m											M	M			M	M	M	M	M	M														M			<15 C		JM
	AM			M	M	<200 m											M	M			M	M	M	M	M	M														M	M		<15 C		AM
	AF	M	M																																										AF
Coho Salmon	EL	M																												M	M														EL
	JF	M																																					M	M	M				JF
	JE		M	M																																			M						JE
	JM		M	M	M	<50 m											M	M			M	M	M	M	M	M													M				<15 C		JM
	AM			M	M	<200 m											M	M			M	M	M	M	M	M													M	M			<15 C		AM
	AF	M	M																																										AF
Pink Salmon	EL	M	M				M																							M	M														EL
	JF	M																																					M						JF
	JE		M	M																																			M						JE
	JM		M	M	M	<50 m											M	M			M	M	M	M	M	M													M	M			<15 C		JM
	AM			M	M	<200 m											M	M			M	M	M	M	M	M													M	M			<15 C		AM
	AF	M	M				M																																						AF
Chum Salmon	EL	M	M				M																							M	M														EL
	JF	M																																							M				JF
	JE		M	M																																					M				JE
	JM		M	M	M	<200 m											M	M			M	M	M	M	M	M													M				<15 C		JM
	AM			M	M	<200 m											M	M			M	M	M	M	M	M													M	M	M		<15 C		AM
	AF	M	M				M																																						AF
Sockeye Salmon	EL	M																												M	M														EL
	JF	M																																						M					JF
	JE		M	M																																				M					JE
	JM		M	M	M	<50 m											M	M			M	M	M	M	M	M														M			<15 C		JM
	AM			M	M	<200 m											M	M			M	M	M	M	M	M													M	M			<15 C		AM
	AF	M	M																																										AF

		KNOWN LIFE HISTORY TRAITS																										
		Feeding Type						Movements							Social Behavior					Duration of Life Stage/Adult Longevity								
	Life Stage/Activity	Piscivore	Herbivore	Omnivore	Planktivore	Detritivore	Insectivore	Drift With Ocean Conditions	Reside in Nursery Areas	North/South Migrations	Inshore/Offshore Migrations	Sedentary	Diel or Diurnal	Not Known	Solitary	Non-Random Associations	Schooling	Shoaling	Not Known	1 Day	1 - 30 Days	1 - 12 Months	1 - 5 Years	5 - 20 Years	20 - 50 Years	> 50 Years	Not Known	Life Stage/Activity
Chinook Salmon	JF	**M**					**M**		**M**						**M**								**M**					JF
	JE	**M**			**M**		**M**											**M**			**M**							JE
	JM	**M**								**M**	**M**		**M**					**M**				**M**						JM
	AM	**M**								**M**	**M**		**M**					**M**					**M**					AM
Coho Salmon	JF	**M**					**M**		**M**						**M**								**M**					JF
	JE	**M**			**M**		**M**											**M**			**M**							JE
	JM	**M**								**M**	**M**		**M**					**M**				**M**						JM
	AM	**M**								**M**	**M**		**M**					**M**				**M**						AM
Pink Salmon	JF								**M**				**M**		**M**						**M**							JF
	JE				**M**													**M**			**M**							JE
	JM				**M**					**M**	**M**		**M**					**M**				**M**						JM
	AM				**M**					**M**	**M**		**M**					**M**				**M**						AM
Chum Salmon	JF						**M**		**M**						**M**						**M**							JF
	JE				**M**													**M**			**M**							JE
	JM				**M**					**M**	**M**		**M**					**M**				**M**						JM
	AM				**M**					**M**	**M**		**M**					**M**					**M**					AM
Sockeye Salmon	JF				**M**		**M**		**M**				**M**		**M**								**M**					JF
	JE				**M**													**M**			**M**							JE
	JM				**M**					**M**	**M**		**M**					**M**				**M**						JM
	AM				**M**					**M**	**M**		**M**					**M**					**M**					AM

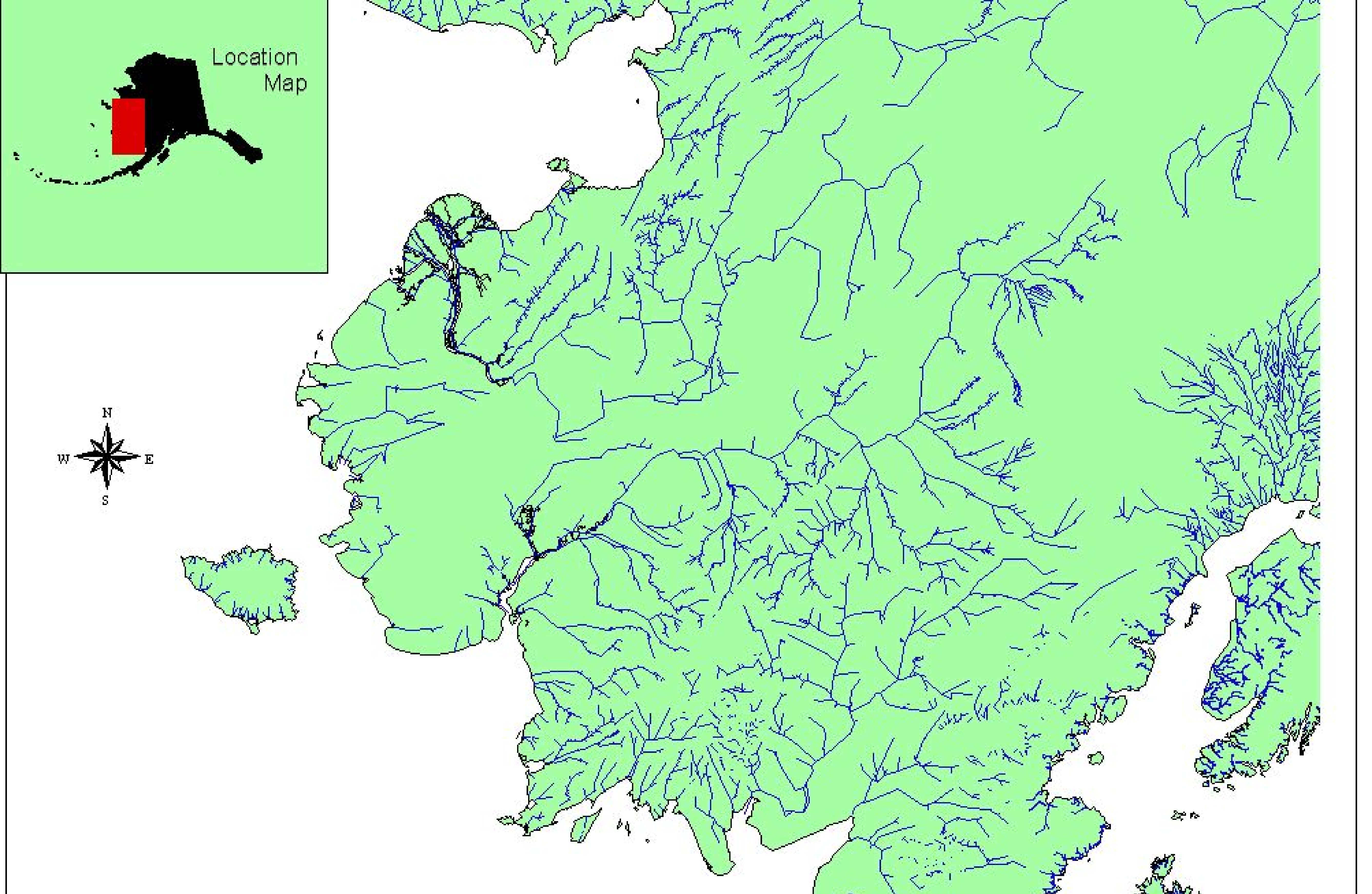
Life stages: JF = Juvenile in fresh water, JE = Juvenile estuarine, JM = Juvenile marine, AM = Immature and maturing adults.

	REPRODUCTIVE TRAITS																								
	Age of Maturity (# annuli)						Fertilization/Egg Development					Spawning Behavior						Spawning Season							
	Female			Male																					
	First	50%	100%	First	50%	100%	External	Internal	Oviparous	Ovoviviparous	Viviparous	Batch Spawner	Broadcast Spawner	Egg Case Deposition	Nest Builder	Egg/Young Guarder	Egg/Young Bearer	Early Spring	Late Spring	Early Summer	Late Summer	Early Fall	Late Fall	Early Winter	Late Winter	Not Known
Chinook Salmon	3		7	1		7	**M**		**M**						**M**						**M**	**M**	**M**			
Coho Salmon	2		4	1		4	**M**		**M**						**M**							**M**	**M**	**M**		
Pink Salmon	1		1	1		1	**M**		**M**						**M**						**M**	**M**	**M**			
Chum Salmon	1		4	1		4	**M**		**M**						**M**						**M**	**M**	**M**	**M**		
Sockeye Salmon	3		6	1		6	**M**		**M**						**M**						**M**	**M**	**M**	**M**		

Southeast Alaska Salmon Habitat



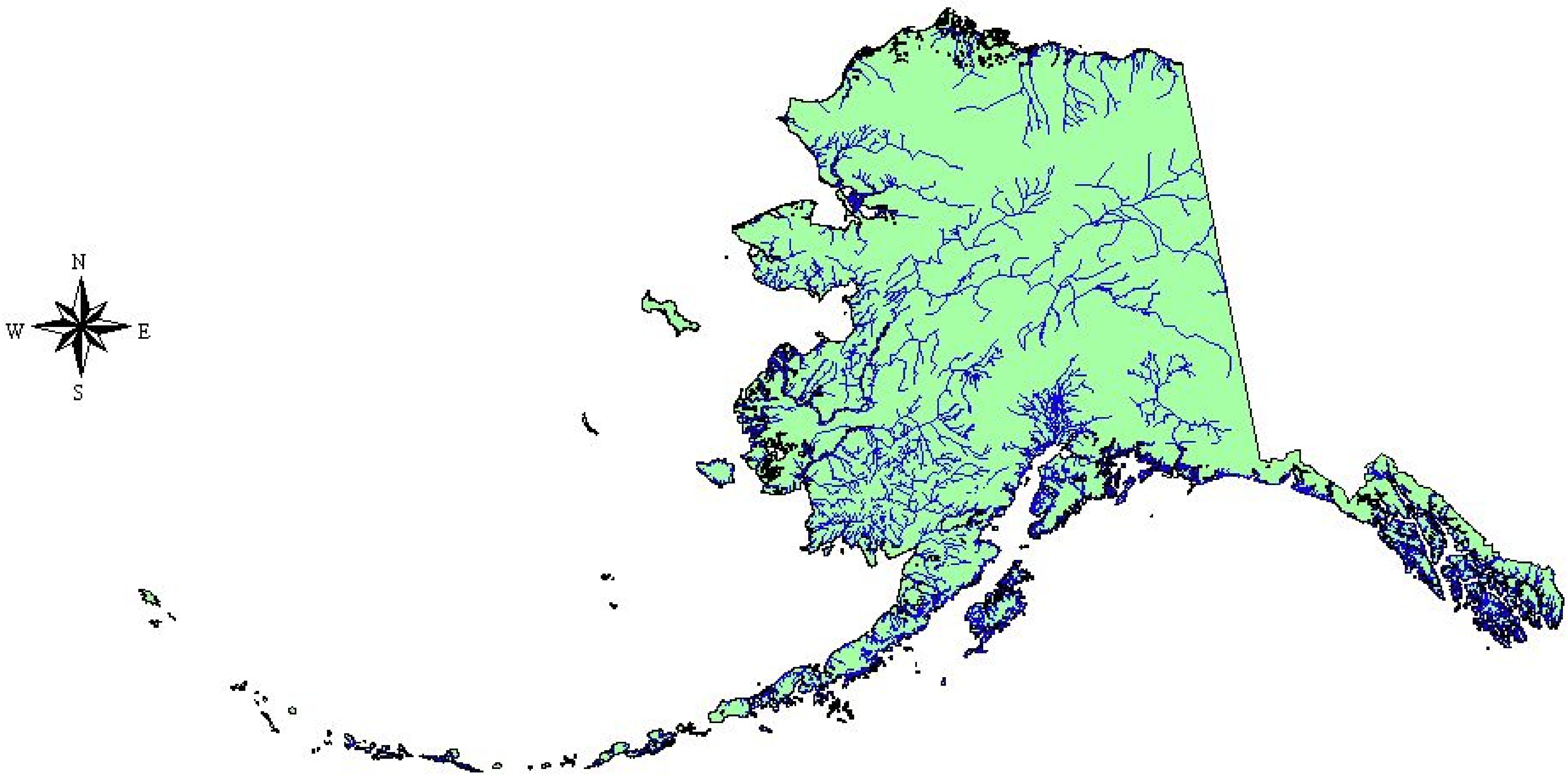
General Distribution of Eggs and Larvae, Freshwater Juvenile and Adult Chinook, Chum, Coho, Pink, and Sockeye Salmon

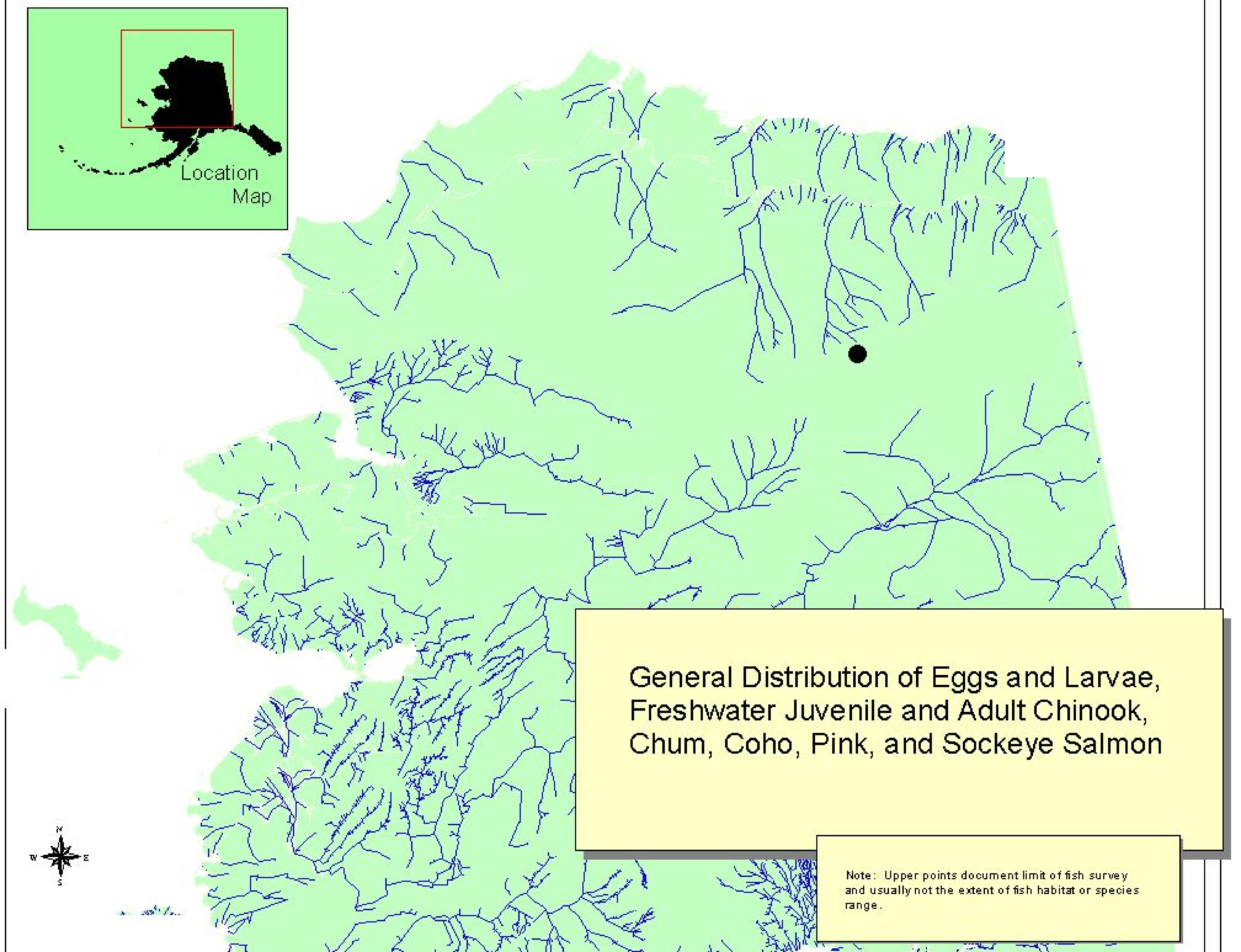


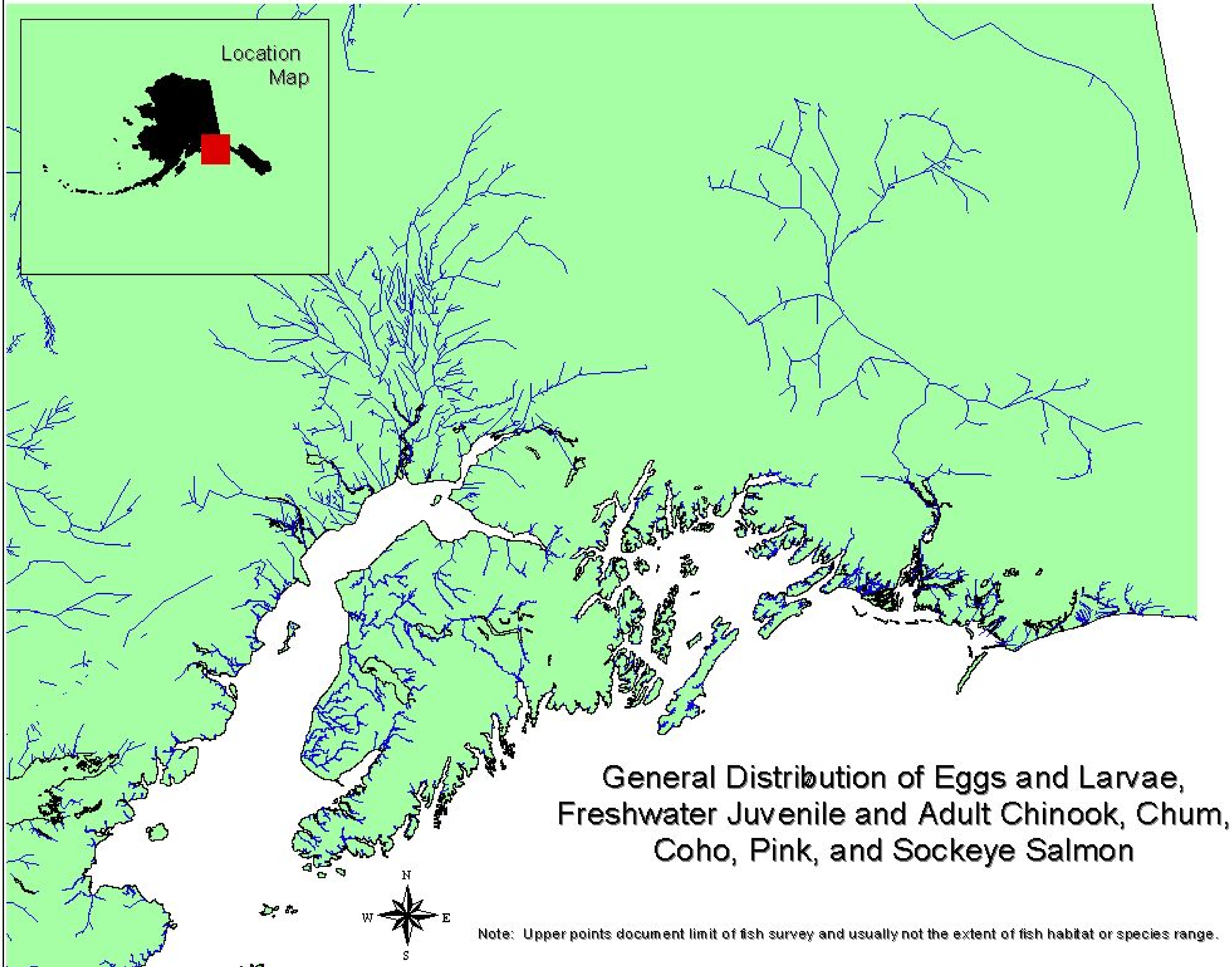
General Distribution of Eggs and Larvae, Freshwater Juvenile and Adult Chinook, Chum, Coho, Pink, and Sockeye Salmon

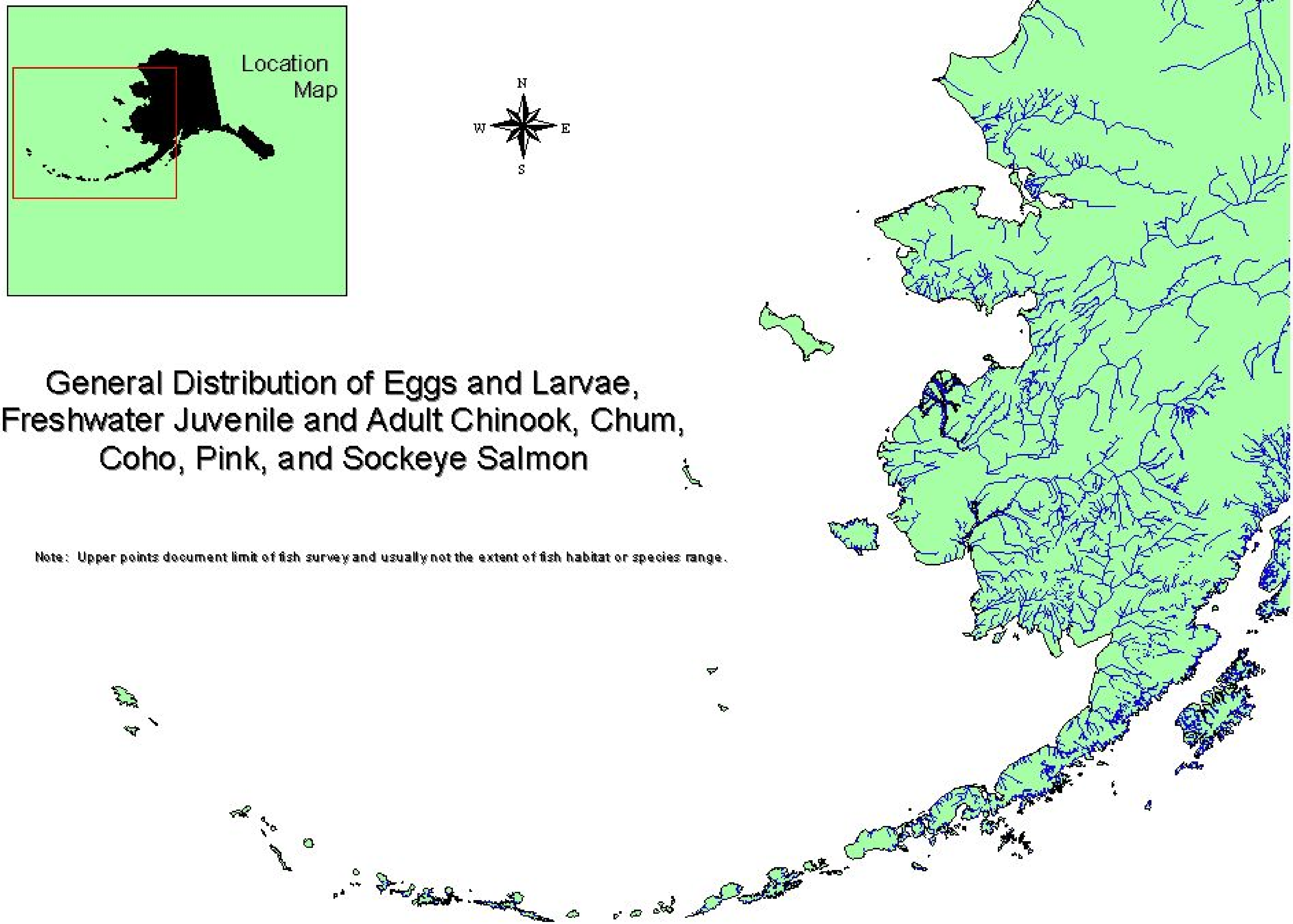
Note: Upper points document limit of fish survey and usually not the extent of fish habitat or species range.

General Distribution of Eggs and Larvae, Freshwater Juvenile and Adult Chinook, Chum, Coho, Pink, and Sockeye Salmon



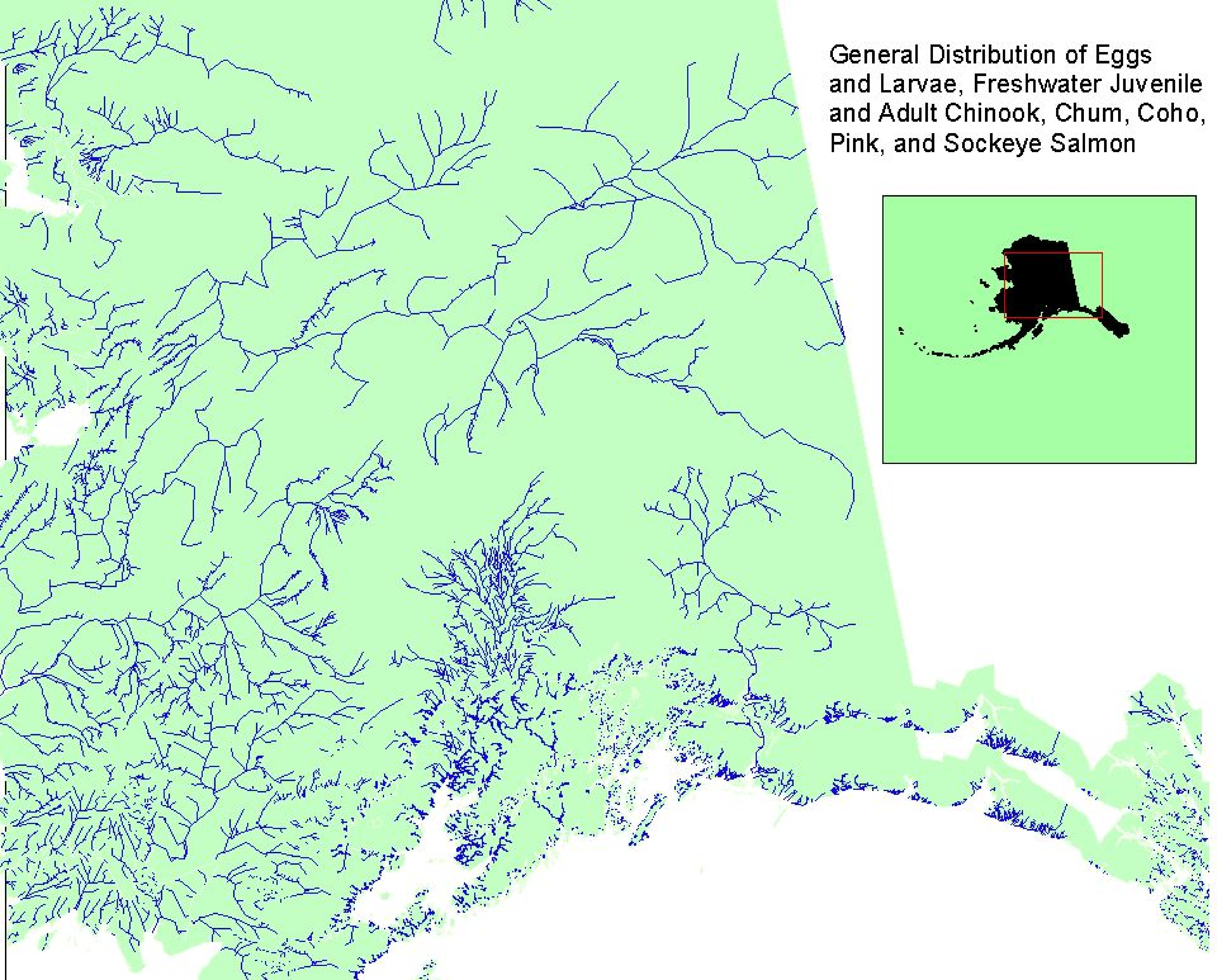

Location
Map
General Distribution of Eggs and Larvae,
Freshwater Juvenile and Adult Chinook,
Chum, Coho, Pink, and Sockeye Salmon
Note: Upper points document limit of fish survey and usually not the extent of fish habitat or species range.
N
W
E
S


Location
Map
General Distribution of Eggs and Larvae,
Freshwater Juvenile and Adult Chinook, Chum,
Coho, Pink, and Sockeye Salmon
N
W
E
S
Note: Upper points document limit of fish survey and usually not the extent of fish habitat or species range.



General Distribution of Eggs and Larvae, Freshwater Juvenile and Adult Chinook, Chum, Coho, Pink, and Sockeye Salmon

Note: Upper points document limit of fish survey and usually not the extent of fish habitat or species range.



General Distribution of Eggs and Larvae, Freshwater Juvenile and Adult Chinook, Chum, Coho, Pink, and Sockeye Salmon

7.0 HABITAT INFORMATION FOR GOA AND BSAI FORAGE FISH

7.1 Amendment 36/39 Background

Amendment 36 to the BSAI groundfish FMP and Amendment 39 to the GOA groundfish FMP defines a forage fish species category in both FMPs and implement associated management measures. The intended effect of this action is to prevent the development of a commercial directed fishery for forage fish, which are a critical food source for many marine mammal, seabird and fish species. Forage fish are abundant fishes that are preyed upon by marine mammals, seabirds and commercially important groundfish species. Prior to regulations implemented under these amendments, the FMP structure potentially could have allowed unrestricted commercial harvest to occur on forage fish species because these species were grouped into the "other species" and non-allocated categories of the FMPs.

Because amendments 36/39 established forage fish as a separate category in the groundfish FMPs, <u>EFH must be defined for these species.</u> The forage fish species category includes all species of the following families:

Osmeridae (eulachon, capelin and other smelts),
Myctophidae (lanternfishes),
Bathylagidae (deep-sea smelts),
Ammodytidae (Pacific sand lance),
Trichodontidae (Pacific sand fish),
Pholidae (gunnels),
Stichaeidae (pricklebacks, warbonnets, eelblennys, cockscombs and shannys),
Gonostomatidae (bristlemouths, lightfishes, and anglemouths),and
the Order Euphausiacea (krill).

7.2 Biological Information on Forage Fish

Because information on forage fish was not included in the Preliminary Essential Fish Habitat Assessment Reports, we have included all available information here that was used by NMFS for their EFH recommendations.

Forage fish species are abundant fishes that are preyed upon by marine mammals, seabirds and other commercially important groundfish species. Forage fish perform a critical role in the complex ecosystem functions of the Bering Sea and Aleutian Islands management area and the Gulf of Alaska by providing the transfer of energy from the primary or secondary producers to higher trophic levels. This analysis has grouped the following forage fish species into the new category: Osmeridae (which includes capelin and eulachon), Myctophidae, Bathylagidae, Ammodytidae, Trichodontidae, Pholidae, Stichaeidae, Gonostomatidae, and the Order Euphausiacea.

7.2.1 Abundance, Distribution, and Food Habits

Forage fishes as a group occupy a nodal or central position in the North Pacific food web, being consumed by a wide variety of fish, marine mammals and seabirds.

Many species undergo large, seemingly unexplainable fluctuations in abundance. Most of these are R-selected species (e.g. pollock, herring, Atka mackerel, capelin, sand lance), which generally have higher reproductive rates, are shorter-lived, attain sexual maturity at younger ages, and have faster individual growth rates than K-selected species (e.g., rockfish, many flatfish). Predators which utilize r-selected fish species as prey (marine mammals, birds and other fish) have evolved in an ecosystem in which fluctuations and changes in relative abundances of these species have occurred. Consequently, most of them, to some degree, are generalists who are not dependent on the availability of a single species to sustain them, but on a suite of species any one (or more) of which is likely to be abundant each year.

There is some evidence, mostly anecdotal, that osmerid abundances, particularly capelin and eulachon, have declined significantly since the mid 1970s. Evidence for this comes from marine mammal food habits data from the Gulf of Alaska (Calkins and Goodwin 1988), as well as from data collected in biological surveys of the Gulf of Alaska (not designed to sample capelin; Anderson et al. in press) and commercial fisheries bycatch from the eastern Bering Sea (Fritz et al. 1993). It is not known, however, whether smelt abundances have declined or whether their populations have redistributed vertically, due presumably to warming surface waters in the region beginning in the late 1970s. This conclusion could also be drawn from the data presented by Yang (1993), who documented considerable consumption of capelin by arrowtooth flounder, a demersal lower-water column feeder, in the Gulf of Alaska.

<u>Smelts (Capelin, Rainbow Smelt and Eulachon)</u>. Smelts (family Osmeridae) are slender schooling fishes that can be either marine (such as capelin) or anadromous (rainbow smelt and eulachon). Figure 8.1 shows a generalized distribution of these three smelt species in the southeastern Bering Sea based on data collected by NMFS summer groundfish trawl surveys and by fisheries observers.

Capelin are distributed along the entire coastline of Alaska and south along British Columbia to the Strait of Juan de Fuca. In the North Pacific, capelin can grow to a maximum of 25 cm at age 4. Most capelin spawn at age 2-3, when they are only 11-17 cm (Pahlke 1985). Spawning occurs in spring in intertidal zones of coarse sand and fine gravel--especially in Norton Sound, northern Bristol Bay and Kodiak. Very few capelin survive spawning. The age of maturity of capelin in the Barents Sea has been shown to be a function of growth rate, with fast-growing cohorts reaching maturity at an earlier age than slow-growing cohorts. Thus, it is possible to have slow and fast-growing cohorts mature in the same year, resulting in large spawning biomasses one year preceded and potentially followed by small spawning biomasses.

In the Bering Sea adult capelin are only found near-shore during the months surrounding the spawning run. During other times of the year, capelin are found far offshore in the vicinity of the Pribilof Islands and the continental shelf break. The seasonal migration may be associated with the advancing and retreating polar ice front, as it is in the Barents Sea. In the eastern Bering Sea, winter ice completely withdraws during the summer months. If migration follows the ice edge, the bulk of the capelin biomass in the Bering Sea could be located in the northern Bering Sea, beyond the area worked by the groundfish fisheries and surveys. Very few capelin are found in surveys, yet they are a major component of the diets of marine mammals feeding along the winter ice edge (Wespestad 1987), and of marine birds, especially in the spring. In the Gulf of Alaska, which remains ice free year round, capelin overwinter in the bays of Kodiak Island and in Kachemak Bay.

Rainbow smelt ascend rivers to spawn in spring shortly after the breakup of the ice. After spawning, they return to the sea to feed. Surveys have found concentrations of rainbow smelt off Kuskokwim Bay, Togiak Bay and off Port Heiden, but they also probably occur in many nearshore areas near river mouths. Rainbow smelt mature at ages 2-3 (19-23 cm), but can live to be as old as 9 years and as large as 30 cm. Little is known about trends in abundance of this species.

Eulachon also spawn in spring in rivers of the Alaska Peninsula, and possibly other rivers draining into the southeastern Bering Sea. Eulachon live to age 5 (and grow to 25 cm), but most die following first spawning at age 3. Eulachon are consistently found by groundfish fisheries and surveys between Unimak Island and the Pribilof Islands in the Bering Sea, and in Shelikof Strait in the Gulf of Alaska (Figure 8.1).

Evidence from fishery observer and survey data suggests that eulachon abundances declined in the 1980s (Fritz et al. 1993). These data should be interpreted with caution since surveys were not designed to sample small pelagic fishes such as eulachon, and fishery data was collected primarily for total catch estimation of target groundfish. Causes of the decline, if real, are unknown, but may be related to variability in year-class strength as noted for capelin.

Pacific Sand Lance (Ammodytidae). Pacific sand lance are usually found on the bottom, at depths between 0-100 m except when feeding (pelagically) on crustaceans and zooplankton. Spawning is believed to occur in winter. Sand lance mature at ages 2-3 years and lengths of 10-15 cm. Little is known of their distribution and abundance; they are rarely caught by trawls. In the Bering Sea, sand lance are common prey of salmon, northern fur seals and many species of marine birds. Thus, they may be abundant in Bristol Bay, along the Aleutian Islands and Alaska Peninsula. In the Gulf of Alaska, sand lance are prey of harbor seals, northern fur seals and marine birds, especially in the Kodiak area and along the southern Alaska Peninsula. Given the sand lance's short life span and the large number of species which prey on it, mortality, fecundity and growth rates of Pacific sand lance are probably high.

Myctophidae and Bathylagidae. Myctophids (lanternfishes) and bathylagids (deep-sea smelts) are distributed pelagically in the deep sea throughout the world's ocean. Most species in both families occur at depth during the day and migrate to near the surface to feed (and be fed upon) at night. A common myctophid in the Bering Sea and Gulf of Alaska is the northern lampfish (*Stenobrachius leucopsarus*), which has a maximum length of approximately 13 cm. Bathylagids of the north Pacific include *Bathylagus* spp. (blacksmelts) and *Leuroglossus stilbius schmidti* (northern smoothtongue), each of which have maximum lengths of between 12-25 cm. Myctophids and bathylagids are important forage fishes for marine birds and marine mammals. Since they are rarely caught in survey or fishery trawls, nothing is known of recent trends in their abundance.

Pacific sandfish (Trichodontidae). The Pacific sandfish (*Trichodon trichodon*) lives in shallow inshore waters to about 50 m depth and grows to a maximum length of 30 cm. Nothing is known of trends in their abundance. They are feed upon by salmon and other fish, as well as pinnipeds.

Euphausiids. Along with many copepod species, the euphausiids form a critical zooplanktonic link between the primary producers (phytoplankton) and all upper pelagic trophic levels. These crustaceans, also known as krill, occur in large swarms in both neritic and oceanic waters. Members of at least 11 genera of euphausiids are known from the North Pacific, the most important (in terms of numbers of species) being *Thysanopoda*, *Euphausia*, *Thysanoëssa* and *Stylocheiron* (Boden et al. 1955; Ponomoreva 1963). Euphausiids are generally thought to make diurnal vertical migrations, remaining at depth (usually below 500 m) during the day and ascending at night to 100 m or less. However, this is complicated by the fact that as euphasiids grow they are found at deeper depths, except during spawning, which occurs in surface waters. Spawning occurs in spring to take advantage of the spring phytoplankton bloom, and the hatched nauplii larvae live near the surface (down to about 25 m). By fall and winter, the young crustaceans are found mainly at depths of 100 m or less, and make diurnal vertical migrations. Sexual maturity is reached the following spring at age 1. After spawning, adult euphausiids gradually descend to deeper depths until fall and winter, when they no longer migrate daily to near-surface waters. In their second spring, they again rise to the surface to spawn; euphausiids older than 2 years are very rarely found. This classical view of euphausiid life history and longevity was recently questioned by Nicol (1990), who reported that Antarctic euphausiids may live as long as 6-10 years; annual euphausiid production, then, would be much lower than if they lived only 2 years.

While euphausiids are found throughout oceanic and neritic waters, their swarms are most commonly encountered in areas where nutrients are available for phytoplankton growth. This occurs primarily in areas where upwelling of waters from depth into the surface region is a consistent oceanographic feature. Areas with such features are at the edges of the various domains on the shelf or at the shelf-break, at the heads of submarine canyons, on the edges of gullies on the continental shelf (e.g., Shumagin, Barnabus, Shelikof gullies in the Gulf of Alaska), in island passes (on certain tides) in the Aleutian Islands (e.g., Seguam Pass, Tanaga Pass), and around submerged seamounts (e.g. , west of Kiska Island). It is no coincidence that these are also prime fishing locations used by commercial fishing vessels seeking zooplanktivorous groundfish, such as walleye pollock, Atka mackerel, sablefish and many species of rockfish and flatfish (Livingston and Goiney 1983; Fritz 1993; Yang 1993).

The species comprising the euphausiid group occupy a position of considerable importance within the North Pacific food web. Euphausiids are fed upon by almost all other major taxa inhabiting the pelagic realm. The diet of many species of fish other than the groundfish listed above, including salmon, smelts (capelin, eulachon, and other osmerids), gadids (Arctic cod and Pacific tomcod), and Pacific herring is composed, to varying degrees, by euphausiids (Livingston and Goiney 1983), while euphausiids are the principal item in the diet of most baleen whales (e.g. minke, fin, sei, humpback, right, and bowhead whales; Perez 1990). While copepods generally constitute the major portion of the diet of planktivorous birds (e.g. auklets), euphausiids are prominent in the diets of some predominately piscivorous birds in some areas (e.g. kittiwakes on Buldir Island in the Aleutians, Middleton Island in the Gulf of Alaska, and St. Matthew Island in the Bering Sea; Hatch et al. 1990). Euphausiids are not currently sought for human use or consumption from the North Pacific ocean on a scale other than local, but large (about 500,000 mt per year) krill fisheries from Japan and Russia have been operating in Antarctic waters since the early 1980s (Swartzman and Hofman 1991).

Pholidae (Gunnels) and Stichaeidae (Pricklebacks, Warbonnets, Eelblennys, Cockscombs and Shannys). Gunnels and pricklebacks are long, compressed, eel-like fishes with long dorsal fins often joined with the caudal fin. Pricklebacks are so named because all rays in the dorsal fin are spinous in most species (while some may have soft rays at the rear of the dorsal fins). Gunnels have flexible dorsal fin rays, and differ from pricklebacks in that the anal fin is smaller (the distance from the tip of the snout to the front of the anal fin is shorter than the length of the anal fin). Most species of both families live in shallow nearshore waters among seaweed and under rocks and are mostly less than 45 cm in length. There are approximately 14 species of Stichaeidae and 5 species of Pholidae in Alaska. Nothing is known about absolute or trends in their abundance, and little about their growth rates, maturity schedules, and trophic relationships. They feed mostly on small crustacea and arthropods, and are thought to grow quickly. Some cockscombs in British Columbia attain sexual maturity at age 2 years.

Gonostomatidae (Bristlemouths, Lightfishes, Anglemouths). This is a large and diverse family of small (to about 8 cm), bathypelagic fish that are rarely observed except by researchers. They can be abundant at depths of up to 5000 m. There may be as many as 6 species in the North Pacific Ocean and Bering Sea.

7.2.2 Diets of Forage Fish Species in the North Pacific

Bathylagid. Since bathylagids have a small mouth, dense flat gill rakers, a small stomach and long intestine, they consume weak swimming soft-bodied animals (pteropods, appendicularia, ctenophores, chaetognath, polychaete, jellyfish etc.). Bathylagids in the epipelagic zone can also feed on euphausiids and copepods at night when they are abundant (Gorelova and Kobylyanskiy, 1985; Balanov, et al., 1995).

Myctophid. Because of their large mouth, relatively sparse and denticulate gill rakers, well developed stomach and short intestine, myctophids mostly consume actively swimming animals like copepods and euphausiids (Balanov, et al. 1995).

Pacific sandfish. The diet of sandfish consists of small crustaceans such as mysids, amphipods, and cumaceans (Mineva 1955, Kenyon 1956).

Eulachon. The diet of eulachon in the North Pacific generally consists of planktonic prey (Hart, 1973; Macy et al., 1978). As larvae they primarily consume copepod larvae; post-larvae consume a wider variety of prey that includes phytoplankton, copepod eggs, copepods, mysids, ostracods, barnacle larvae, cladocerans worm larvae and larval eulachon. Juvenile and adult eulachon feed almost exclusively on euphausiids, with copepods and cumaceans occasionally in the diet.

Sand lance. Hart (1973) and Trumble (1973) summarized the diet of sand lance in the North Pacific as primarily planktivorous; their primary prey changing with ontogeny. Larval sand lance consume diatoms and dinoflagellates; post-larvae prey upon copepods and copepod nauplii. Adult sand lance prey upon chaetagnaths, fish larvae, amphipods, annelids and common copepods. Sand lance exhibit seasonal and diurnal variation in feeding activity and are opportunistic feeders upon abundant plankton blooms.

Capelin. The diet of capelin in the north Pacific as summarized by Hart (1973) and Trumble (1973) is primarily planktivorous. Small crustaceans such as euphausiids and copepods are common to the diet of capelin, although marine worms and small fish are also part of their diet. In the Bering Sea, adult capelin consume copepods, mysids, euphausiids, and chaetognaths. Juveniles primarily consume only copepods (Naumenko, 1984). The largest capelin (>13cm) consume euphausiids nearly exclusively. Capelin feed throughout the year in the Bering Sea. However, the diet exhibits seasonal variation that is due in part to spawning migration and behavior.

The primarily planktivorous diets of eulachon, sand lance, and capelin reduce the potential for dietary competition with the piscivorous and benthic diets of most groundfish. However, the potential for dietary competition is greater between pollock and forage fish due to the importance of planktonic prey such as euphausiids and copepods in their diets.

Gonostomatid. Gonostomatids have large gill openings and well-developed gill rakers, characteristics of a zooplankton feeder. The primary zooplankton prey of gonostomatids are calanoid copepods. The other food includes ostracods and euphausiids. Some larger gonostomatids also consume some fish (Gorelova 1980).

Stichaeidae. There are many species in the Family Stichaeidae, a family with long, slender, compressed bodies. Some of the diets of the stichaeids are described below. The longsnout prickleback eats copepods almost exclusively (Barraclough 1967). Young ribbon pricklebacks eat copepods and oikopleura (Robinson, Barraclough and Fulton 1968). The food of the adults of this species includes crustaceans and red and green algae. Black prickleback consumed copepods, copepod nauplii and clam larvae (Barraclough, Robinson, and Fulton 1968). Peppar (1965) reported that the important food of high cockscomb was green algae. Other food of this species included polychaete worms, amphipods, molluscs, and crustaceans.

Euphausiacea. The diets of euphausiids in the North Pacific consist of planktonic prey. Species of the genus Euphausia consume diatoms, dinoflagellates, tintinnids, chaetagnaths, echinoderm larvae, amphipods, crustacean larvae, ommatidians, and detritus (Mauchline 1980). Species of the genus

Thysannoessa consume diatoms, dinoflagellates, tintinnids, radiolarians, foraminiferans, chaetagnaths, echinoderm larvae, molluscs, crustacean larvae, ommatidians and detritus (Mauchline 1980). Several species of Thysannoessa also consume walleye pollock eggs in the Gulf of Alaska (Brodeur and Merati 1993).

Pholidae. The diets of gunnels (family Pholidae) consists primarily of benthic and epibenthic prey. Amphipods, isopods, polychaete worms, harpacticoid copepods, cumaceans, munid crabs, insects, mysids, algae, ostracods, bivalves, crustacean larvae, and tunicates have been described as their main prey (Clemens and Wilby 1961, Simenstad et al. 1979, Williams 1994). Juvenile fish prey (English sole, *Parophry vetulus*, and sand lance, *Ammodytes hexapterus*) have also been described as infrequent components of the diet in Puget Sound, Washington (Simenstad et al. 1977).

7.2.3 Significance of Forage Fish in the Diet of Groundfish

Bering Sea

Forage fish, as defined in this EA, are found in the diets of walleye pollock, Pacific cod, arrowtooth flounder, Pacific halibut, Greenland halibut, yellowfin sole, rock sole, Alaska plaice, flathead sole, and skates in the eastern Bering Sea region. However, forage fish do not represent a large portion of the diet by weight of these predators with the exception of shelf rock sole (14.3%) and slope pollock (12.6%).

Eastern Bering Sea Shelf. Despite the generally piscivorous diet of cod, arrowtooth flounder, Pacific halibut, Greenland turbot and skates, forage fish are not principal components in the diet by weight. Sand lance are the most prevalent forage fish in the diet of cod (0.8%) while capelin, Osmeridae, Bathylagidae, Myctophidae, and eulachon each represent 0.1% or less of the diet by weight. In the diet of arrowtooth flounder, capelin and eulachon each represent 0.2% of the diet by weight, while Osmeridae, Myctophidae, and sand lance each constitute 0.1% or less. The diet of Pacific halibut contains 2.2% sand lance and 1.8% capelin; Osmeridae and eulachon each represent 0.1% or less. Myctophidae represent 0.2% of the diet of Greenland turbot; Bathylagidae, Osmeridae, and sand lance represent 0.1% or less. Sand lance are the most important forage fish in the diet of skates (0.7%); capelin, sandfish, and Myctophidae each represent 0.1% or less.

Sand lance is the most prevalent forage fish species in the diet of walleye pollock (0.5%); Osmeridae, Bathylagidae, Myctophidae, and eulachon each represent <0.1% of the diet by weight. The total contribution (0.6%) of forage fishes to the diet of yellowfin sole is primarily due to sand lance; Bathylagidae and capelin each represent <0.1% by weight. Sand lance are the second most important prey in the diet of rock sole, 14.3% by weight; Osmeridae are the only other forage fish present in the diet (<0.1%). Sand lance are the only forage fish found in the diet of Alaska plaice, representing 0.5% of the diet. Flathead sole consumes capelin (1.3%), sand lance (0.5%), Osmeridae (0.1%) and Myctophidae (<0.1%).

Eastern Bering Sea Slope. Lang and Livingston (1996) studied the diets of groundfish in the eastern Bering Sea slope region. In this region, forage fish are relatively unimportant in the diets of Greenland halibut, flathead sole, arrowtooth flounder, and cod. However, 12.6 % of the diet of pollock on the slope consists of forage fishes. Greenland halibut consume Bathylagidae (0.4%) and Myctophidae (0.4%) as the only forage fish in their diet. Flathead sole also consumed Bathylagidae (0.3%) and Myctophidae (0.1%). Myctophidae (0.2%) is the only forage fish found in the diet of arrowtooth flounder. Pollock consume Bathylagidae (7.0%), Myctophidae (5.5%), Osmeridae (0.1%), and sand lance (<0.1%). Forage fish are negligible in the diet of cod; Bathylagidae represent <0.1% of the diet by weight.

Gulf of Alaska

Yang (1993) studied the diets of groundfish in the Gulf of Alaska shelf during summer. He found that the main fish prey of groundfish in the Gulf of Alaska included walleye pollock, Pacific herring, capelin, Pacific sand lance, eulachon, Atka mackerel, bathylagids, and myctophids. Although walleye pollock was the most important fish prey of arrowtooth flounder, Pacific halibut, sablefish, Pacific cod, and walleye pollock in the Gulf of Alaska area, other forage fish species comprised 1-18% of the diet of groundfish. Capelin was important food of arrowtooth flounder and pollock, comprising 8% and 13 % of the diet of arrowtooth flounder and walleye pollock, respectively. The capelin consumed by these groundfish were mainly located in the northeast and southwest of Kodiak Island. Eulachon comprised 6% of the food of sablefish. Myctophids were important forage fish for shortraker rockfish, comprising 18% of the diet of shortraker rockfish. Pacific sand lance were found in the stomachs of arrowtooth flounder, Pacific halibut, sablefish, Pacific cod, and walleye pollock, but its contribution to the diet was small (≤1 %). Bathylagids were only found in the diet of walleye pollock, they contributed less than 1% of the diet of walleye pollock. Pacific sandfish was not found in the diet of the groundfish in the Gulf of Alaska area.

In the Atlantic, strong interactions between cod and capelin have been recorded (Akenhead, et al. 1982). Even though Pacific cod did not feed so heavily on capelin in the Gulf of Alaska, capelin was one of the important fish prey of several groundfish species. The distributions and the abundances of the forage fish in the Gulf of Alaska are not well known. However, a series of years with poor forage fish recruitment, which decreases the availability of small fish, may have greater impact on piscivorous groundfishes.

Aleutian Islands

Yang (1996) studied the diets of groundfish in the Aleutian Islands during summer. He found that main fish prey of groundfish in the Aleutian Islands included Atka mackerel, walleye pollock, Pacific herring, capelin, myctophids, bathylagids, Pacific sand lance, and eulachon. Although Atka mackerel and walleye pollock were important fish prey of arrowtooth flounder, Pacific halibut, and Pacific cod, other forage fish species comprised from 1-37% of the diet of groundfish. Most of the Atka mackerel consumed by the groundfish were located near Attu, Agattu, Amchitka, Tanaga, Atka, and Unalaska Islands. Myctophids were an important forage fish. Large amounts of myctophids were found in the diets of Greenland turbot, walleye pollock, Pacific ocean perch, and short raker rockfish. They were also found in arrowtooth flounder, Pacific cod, rougheye rockfish, Atka mackerel, and northern rockfish. Most myctophids consumed by the groundfish were located near Kiska, Adak, Seguam, and Yunaska Islands. It is notable that nine out of eleven groundfish species shown in Table 4 consumed myctophids as food. If the abundance of the myctophids declines dramatically, it could impact the growth of groundfish in the Aleutian Islands area which depend on myctophids for a main food resource. Bathylagids were found in the diets of Greenland turbot and walleye pollock. Capelin were found in the diet of Pacific halibut and walleye pollock collected in the Akutan Island area, but they contributed only 5% and less than 1% of the diets of Pacific halibut and walleye pollock, respectively. Pacific sand lance were food of arrowtooth flounder, Pacific halibut, Pacific cod, and walleye pollock, but they contributed less than 1% of the diets. Only a small amount (less than 1%) of eulachon was found in the diet of walleye pollock. Pacific sandfish was not found in the diets of the groundfish in the Aleutian Islands area.

Other Forage Species in the Diets of Bering Sea, Gulf of Alaska, and Aleutian Islands Groundfish

Euphausiacea. Euphausiids represent a significant portion of the diet of walleye pollock in the eastern Bering Sea Shelf region (Livingston 1991a). Euphausiids represent as much as 70% of the diet in the winter and spring and are generally more important to larger pollock than smaller ones. Euphausiids are also the primary prey of small (<35 cm) Greenland turbot in the eastern Bering Sea shelf, but are of little importance to larger fish (Livingston and deReynier 1996). Small (< 35 cm) arrowtooth flounder also consume euphausiids as a large (50% by weight) portion of their diet; euphausiids are of little importance to the larger ones (Livingston and deReynier 1996). Euphausiids were not found as a significant component of the diet of any other eastern Bering Sea shelf groundfish.

In the eastern Bering Sea slope region euphausiids were found in the diets of several groundfish species. Euphausiids represent 26% of the overall diet by weight of walleye pollock but are more important seasonally (80% by weight in winter) and are more important to smaller (<50 cm) fish (Lang and Livingston 1996). Euphausiids also play a small role (<1% by weight) in the diets of Pacific cod, flathead sole, and arrowtooth flounder (Lang and Livingston 1996).

Euphausiids are an important food item of many groundfish species in the Gulf of Alaska and Aleutian Islands areas. Yang (1993) showed that the diets of plankton feeding groundfish in the Gulf of Alaska such as dusky rockfish, Pacific ocean perch, and northern rockfish had large percentages (more than 65%) of euphausiids. Euphausiids also comprised 39% of the diet of walleye pollock in the Gulf of Alaska. In the Aleutian Islands, euphausiids also comprised 43, 55, 51, and 50% of the stomach contents of walleye pollock, Atka mackerel, Pacific ocean perch, and northern rockfish, respectively. Euphausiids were also a constituent of the diets of arrowtooth flounder (5%), rougheye rockfish (2%), shortspine thornyhead (1%), and shortraker rockfish (1%) in the Aleutian Islands. (Yang 1996).

Stichaeids. Stichaeids represent a minimal portion of the diets of several groundfish species in the eastern Bering Sea shelf region. Pacific cod (Livingston 1991b), arrowtooth flounder (Yang 1991a), and flathead sole (Pacunski 1991) consume unidentified stichaeids as < 1% of their diets by weight. Greenland turbot consume a combination of unidentified stichaeids and daubed shanny (*Lumpenus maculatus*) as a small portion (<1%) of their diet.

Stichaeids represent a small portion (<1% by weight) of the diet of Pacific cod, arrowtooth flounder, and Greenland turbot in the eastern Bering Sea slope region (Lang and Livingston 1996). Yang (1993) studied the diets of the groundfish in the Gulf of Alaska area during summer. He found that stichaeids comprised about 1% of the stomach content weight of arrowtooth flounder, Pacific cod, and walleye pollock, respectively. Pacific halibut, sablefish, and Pacific ocean perch also consumed stichaeids, but their contribution to the diets was small (<1%). Yang (1996) also studied the diet of the groundfish in the Aleutian Islands area. He found that stichaeids comprised 2% of the stomach contents weight of arrowtooth flounder. Stichaeids comprised <1% of the diets of Pacific cod, walleye pollock, and Atka mackerel.

Gonostomatids. Gonostomatids were not found as a significant portion of the diets of eastern Bering Sea shelf or slope groundfish (Livingston and deReynier, 1996). Gonostomatids are probably not important prey of the groundfish in the Gulf of Alaska area since they were not found in a recent study of groundfish diets in that area (Yang 1993). Gonostomastids were found in walleye pollock stomachs in the Aleutian Islands area; however, they contributed less than 1% of the total stomach contents weight (Yang 1996).

Pholids. Pholids (saddleback gunnel) were found in the Pacific cod stomachs in the Aleutian Islands area; their contribution was less than 1% of the total stomach contents weight. Pholids were not found as a significant portion of the diets of eastern Bering Sea shelf or slope groundfish. Pholids are probably not important prey of the groundfish in the Gulf of Alaska area since they were not found in a recent study of groundfish diets in that area (Yang 1993).

See table of contents for the following map:

Figure 8.1 Distribution of capelin, rainbow smelt, and eulochon in the Bering Sea, as indicated by the Alaska Fisheries Science Center summer groundfish trawl surveys.

7.2.4 References

Akenhead, S.A., J. Carscadden, H. Lear, G.R. Lilly, and R. Wells. 1982. Cod-capelin interactions off northeast Newfoundland and Labrador. *in* Mercer, M. C. Multispecies approaches to fisheries management advice. PP. 141-148.

Anderson, P. J., S. A. Payne, and B. A. Johnson. 1994. Long-term demersal community structure changes in Pavlof Bay, Alaska. Unpubl. manuscr., 28 p. NMFS-AFSC Kodiak Lab, P.O. Box 1638, Kodiak, AK 99615.

Balanov, A.A., K.M. Gorbatenko, and A.Ya. Efimkin. 1995. Foraging dynamics of mesopelagic fishes in the Bering Sea during summer and autumn. *J. of Ichthyology*. 35(3), pp. 65-77.

Barraclough, W.E. 1967. Data record. Number, size and food of larval and juvenile fish caught with a two boat surface trawl in the Strait of Georgia. April 25-29, 1966. Fish. Res. Board Can. MS Rep. Ser. 922: 54 p.

Barraclough, W.E., D.G. Robinson, and J.D. Fulton. 1968. Data record. Number, size composition, weight, and food of larval and juvenile fish caught with a two-boat surface trawl in Saanich Inlet, April 23-July 21, 1968. Fish. Res. Board Can. MS Rep. Ser. 1004: 305 p.

Boden, B. P., M. W. Johnson, and E. Brinton. 1955. The Euphausiacea (Crustacea) of the North Pacific. Bull. Scripps Institution Oceanography, Univ. CA, 6(8): 287-400.

Brodeur, R. D. and N. Merati. 1993. Predation on walleye pollock (*Theragra chalcogramma*) eggs in the western Gulf of Alaska: the roles of vertebrate and invertebrate predators. *Mar. Biol*. 117:483-493.

Calkins, D., and E. Goodwin. 1988. Investigation of the declining sea lion population in the Gulf of Alaska. Unpubl. Rept. Alaska Dept. Fish and Game, 333 Raspberry Road, Anchorage, AK 99518-1599. 76 p.

Carscadden, J.E. 1984. Capelin in the northwest Atlantic. Pp. 170-183 *in* D.N. Nettleship, G.A. Sanger, and P.F. Springer, eds. Marine birds: their feeding ecology and commercial fisheries relationships. Canadian Wildlife Service, Publication CW66-65/1984.

Castellini, Michael. 1993 Report of the Marine Mammal Working Group. Is it Food? Addressing Marine Mammal and Seabird Declines. Workshop Summary. Alaska Sea Grant Report 93-01.

Francis, R.C., L.G. Anderson, W.D. Bowen, S.K. Davis, J.M. Grebmeier, L.F. Lowry, I. Merculieff, N.S. Mirovitskaya, C.H. Peterson, C. Pungowiyi, T.C. Royer, A.M. Springer, and W.S. Wooster. 1996. The Bering Sea ecosystem: report of the Committee on the Bering Sea Ecosystem, National Research Council. National Academy Press, Washington, D.C.

Fritz, L. W. 1993. Trawl locations of walleye pollock and Atka mackerel fisheries in the Bering Sea, Aleutian Islands, and Gulf of Alaska from 1977-92. AFSC Processed Report 93-08. NMFS, AFSC, 7600 Sand Point Way, NE, Seattle, WA 98115. 162 p.

Fritz, L. W. 1996. Squid and Other Species. P. 13-1 - 13-15 *in* Stock assessment and fishery evaluation report for the groundfish resources of the Bering Sea/ Aleutian Islands regions as projected for 1997. North Pacific Fisheries Management Commission, P.O. Box 103136, Anchorage, AK 99510.

Fritz, L. W., V. G. Wespestad, and J. S. Collie. 1993. Distribution and abundance trends of forage fishes in the Bering Sea and Gulf of Alaska. P. 30-43 *in* Is it food?: addressing marine mammal and sea bird declines. Workshop Summary, Alaska Sea Grant Rept. 93-01. Univ. Alaska, Fairbanks, AK.

Gorelova, T.A. and S.G. Kobylyanskiy. 1985. Feeding of deepsea fishes of the Family Bathylagidae. *J. of Ichthyology*. 25(5): 89-100.

Gorelova, T.A. 1980. Feeding of deep-sea fish of the genus Cyclothone (Gonostomatidae, Pisces). *Oceanology*. Vol. 20:209-214.

Gould, P.J., P. Ostrom, and W. Walker. Trophic relationships of albatrosses associated with squid and large-mesh driftnet fisheries in the North Pacific Ocean. *Canadian Journal of Ecology*, in press.

Hamre, Johannes. 1992. Interrelation Between Environmental Changes and Fluctuating Fish Populations in the Barents Sea.Institute of Marine Research, P.O. Box 1870, N-5024 Bergen-Nordnas, Norway.

Hart, J. L . 1973. Pacific Fishes of Canada. Fish. Res. Bd. Canada, Bull. 180. 740 pp.

Lang, G. M. and P. A. Livingston. 1996. Food habits of key groundfish species in the eastern Bering Sea slope region. U. S. Dep. Commer., NOAA Tech. Memo. NMFS AFSC-297, 110 p.

Livingston, P. A. and Y. deReynier. 1996. Groundfish food habits and predation on commercially important species in the eastern Bering Sea from 1990 to 1992. U.S. Dep. Commer., NOAA Proc. Rep. AFSC 96-04.

Livingston, P. A., and B. J. Goiney, Jr. 1983. Food habits literature of North Pacific marine fishes: a review and selected bibliography. U. S. Dep. Commerc., NOAA Tech. Memo. NMFS F/NWC-54, 81 p.

Livingston, P. A. 1991b. Pacific cod. P. 31-88, *in* Livingston, P. A. (ed.), Groundfish food habits and predation on commercially important prey species in the eastern Bering Sea, 1984-1986. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-F/NWC-207.

Livingston, P. A. 1991a. Walleye pollock. P. 9-30, In Livingston, P. A. (ed.), Groundfish food habits and predation on commercially important preyspecies in the eastern Bering Sea, 1984-1986. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-F/NWC-207.

Macy, P. T., J. M. Wall, N.D. Lampsakis, and J. E. Mason. 1978. Resource of non-salmonid pelagic fishes of the Gulf of Alaska and eastern Bering Sea. U.S. Dept. Commer. NOAA Proc. Rep. 103, Pt. 1, 355 pp.

Mauchline, J. 1980. The Biology of Mysids and Euphausiids. Academic Press, New York, New York, 681 pp.

Mineva, T.A. 1955. Nekotorye dannye po biologii volosozuba obyknovennogo (Some data on the biology of sandfish). Izv. Tikhookean. Nauchno-issled. Inst.Rybn. Khoz. Okeanogr. 43:195-198. In Russian.

Naumenko, E. A. 1984. Diet of Capelin, Mallotus villosus socialis (Osmeridae), in the Bering Sea. *J. Ich.* 24(3) 130-134.

Nicol, S. 1990. The age-old problem of krill longevity. Bioscience 40: 833-836.

Pacunski, R. E. 1991. Flathead sole. P. 163-199 In Livingston, P. A. (ed.), Groundfish food habits and predation on commercially important prey species in the eastern Bering Sea, 1984-1986. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-F/NWC-207.

Pahlke, K. A. 1985. Preliminary studies of capelin (*Mallotus villosus*) in Alaska waters. Alaska Dep. Fish Game, Info. Leaf. 250: 64 p.

Patten, S.M., Jr., and LR. Patten. 1982. Evolution, pathobiology, and breeding ecology of large gulls (*Larus*) in the northeast Gulf of Alaska. U.S. National Oceanic and Atmospheric Administration, Outer Continental Shelf Environmental Assessment Program. Final Report of Principal Investigators 18: 1-352.

Ponomareva, L. A. 1963. Euphausiids of the North Pacific: their distribution and ecology. Akademiya Nauk SSSR. Institut Okeanogolii, Moskva. Translated from Russian, Israel Program for Scientific Translations, Jerusalem, 1966. 154 p.

Robinson, D.G., W.E. Barraclough, and J.D. Fulton. 1968 . Data record: number, size composition, weight and food of larval and juvenile fish caught with a two-boat surface trawl in the Strait of Georgia, May 1-4, 1967. Fish Res. Board Can. MS. Rep. Ser. 964:1-105.

Roper, C. F. E., M. J. Sweeney, and C. E. Nauen. 1984. Cephalopods of the world: an annotated and illustrated catalogue of species of interest to fisheries. FAO Fish. Synop. 125, vol 3. 277 p.

Royer, T.C. 1993. High-latitude oceanic variability associated with the 18.6-year nodal tide. *Journal of Geophysical Research* 98: 4639-4644.

Schaefer, M.B. 1970. Men, birds and anchovies in the Peru current -- dynamic interactions. Transactions of the American Fisheries Society 99: 461-467.

Simenstad, C. A., B. S. Miller, J. N. Cross, K. L. Fresh, S. N. Steinfort, and J. C. Fegley. 1977. Nearshore fish and macroinvertebrate assemblages along the Straight of Juan De Fuca including food habits of nearshore fish. Annual Report to the National Oceanic and Atmospheric Administration. FRI-UW-7729 Fisheries Research Institute, College of Fisheries, University of Washington, Seattle, WA 98195. 159 pp.

Steele, J.H. 1991. Marine functional diversity. *BioScience* 41: 470-474.

Swartzman, G. L., and R. J. Hofman. 1991. Uncertainties and research needs regarding the Bering Sea and Antarctic marine ecosystems. U.S. Dep. Commerc., Nat. Tech. Info. Serv. Publ. No. PB91-201731.

Trumble, R. J. 1973. Distribution, relative abundance, and general biology of selected underutilized fishery resources of the eastern North Pacific Ocean. NORFISH Tech. Rep. 39. 178 pp.

U.S. Fish and Wildlife Service. 1996. Alaska Seabird Colony Catalog--computer database and archives. U.S. Fish and Wildlife Service, Nongame Migratory Bird Program, Anchorage, Alaska.

Uttley, J.D., P. Walton, P. Monaghan, and G. Austin. 1994. The effects of food abundance on breeding performance and adult time budgets of Guillemots *Uria aalge*. *Ibis* 136: 205-213.

Wespestad, V. G. 1987. Population dynamics of Pacific herring (*Clupea palasii*), capelin (*Mallotus villosus*), and other coastal pelagic fishes in the eastern Bering Sea. Pp. 55-60 In Forage fishes of the southeastern Bering Sea. Proceedings of a Conference, November 1986, Anchorage, AK. U.S. Dept Interior, Minerals Management Service, OCS Study MMS 87-0017.

Williams, G. D. 1994. Effects of Habitat Modification on Distribution and Diets of Intertidal Fishes in Grays Harbor Estuary, Washington. M. S. Thesis, Univ. Wash., Seattle, WA 53 pp.

Yang, M-S. 1993. Food habits of the commercially important groundfishes in the Gulf of Alaska in 1990. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-22, 150 p.

Yang, M. S. 1991b. Greenland turbot P.122-142 *in* Livingston, P. A. (ed.), Groundfish food habits and predation on commercially important prey species in the eastern Bering Sea, 1984-1986. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-F/NWC-207.

Yang, M-S. 1996. Diets of the important groundfishes in the Aleutian Islands in summer 1991. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-60, 105 p.

Yang, M. S. 1991a. Arrowtooth flounder. P. 143-162 In Livingston, P. A. (ed.), Groundfish food habits and predation on commercially important prey species in the eastern Bering Sea, 1984-1986. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-F/NWC-207.

8.0 IDENTIFICATION OF IMPORTANT HABITAT FOR NON-FMP SPECIES

Section 303(a)(7) of the Magnuson-Stevens Fishery Conservation and Management Act (MSA) requires the Secretary of Commerce (Secretary) and the Councils to amend FMPs to include the description and identification of essential fish habitat (EFH). Language contained in section 305(b) of the Magnuson-Stevens Act states that "the Secretary, in consultation with participants in the fishery, shall provide each Council with recommendations and information regarding each fishery under that Council's authority to assist it in the identification of essential fish habitat, the adverse impacts on that habitat, and the actions that should be considered to ensure the conservation and enhancement of that habitat." Proposed regulatory guidelines at 50 CFR section 600.805(b) further define the statutory language: "An EFH provision in an FMP must include all fish species in the FMU. An FMP may describe, identify and protect the habitat of species not in an FMU; however, such habitat may not be considered EFH for the purposes of sections 303(a)(7) and 305(b) of the Magnuson Act."(62 FR 19723; April 23, 1997)."

"FMU" or "fishery management unit" is defined at 50 CFR section 600.1 "as a fishery or a portion of a fishery identified in an FMP relevant to the FMP's management objectives. The choice of an FMU depends on the focus of the FMP's objectives, and may be organized around biological, geographic, economic, technical, social, or ecological perspectives." The interim final rule (63FR 66555; December 19, 1997) further clarified this section:

> (b) Optional components. An FMP may include a description and identification of the habitat of species under the authority of the Council, even if not contained in the FMU. However, such habitat may not be EFH. This subpart does not change a Council's ability to implement management measures for a managed species for the protection of another species.

At the Alaska Core Team's meeting in Seattle, WA, in September 1997, a question arose as to whether EFH would have to be developed for all of the species listed in both the GOA and the BSAI groundfish FMPs. Neither the GOA or the BSAI groundfish FMPs use the term "fishery management unit" or "FMU" to describe those species managed under the FMPs. While there are stated management goals and objectives within each groundfish FMP, they alone are not particularly helpful in determining which species are within each FMP's FMU. However, a review of the FMPs in their entirety along with an examination of past and current management practices is informative.

Both groundfish FMPs identify four species categories (there will be five with the addition of a forage fish category, upon approval of Amendments 36/39). The species listed under the categories vary slightly with each FMP but the categories are basically the same in effect. The four categories are: the target species category (pollock, cod, etc.); the "other species" category (sculpins, skates, etc.); the prohibited species category (halibut, herring, etc.); and the nonspecified species category (urchins, rattails, etc.).

Based on a review of the FMP language and the interim final rule, NOAA General Council determined that EFH must be described and identified for those species listed within the target species and other species categories of the GOA and BSAI groundfish FMPs because those species are within the FMPs' FMUs. Conversely, the prohibited species and nonspecified species categories do not appear to be relevant to the FMPs' management objectives and are therefore outside of the FMPs' FMU. Because these species are not within the groundfish FMPs FMUs, there is no requirement to describe and identify EFH for the prohibited species or nonspecified species categories of the GOA and BSAI groundfish FMPs. Nevertheless, "habitat assessments" have been prepared for several non-FMP species (Pacific halibut, Pacific herring, and GOA crab). These species are recognized as important components of the

GOA and BSAI ecosystems. These assessments will be appended to the EFH FMP amendments. However, these assessments will not be considered EFH for the purposes of sections 303(a)(7) and 305(b) of the MSA.

8.1 Pacific Halibut

Habitat and Life History Description for Pacific Halibut
Hippoglossus stenolepis
by
International Pacific Halibut Commission Staff

Life History and Distribution

Pacific halibut are found on the continental shelf of the North Pacific Ocean and the Bering Sea. They have been recorded on the North American coast from Santa Barbara, California to Nome, Alaska and along the Aleutian Islands, and also along the Asiatic Coast from the Gulf of Anadyr, Russia to Hokkaido, Japan. Adult halibut are demersal, living on or near the bottom, and can be found in a wide range of bottom habitat including rock, sand, gravel, and mud. Preferred water temperature is 3 to 8 degrees Celsius (Thompson and VanCleve 1936) although Best and Hardmann (1982) reported finding concentrations of halibut at temperatures as low as 0 degrees Celsius.

From November to March, mature halibut concentrate annually on spawning grounds along the edge of the continental shelf at depths from 185 to 460 meters. The summer months are spent in more shallow coastal waters ranging in depth from 25 to 275 meters.

The major spawning sites in North America are shown in Figure 1 and include Cape St. James, Langara Island (Whaleback), and Frederick Island in British Columbia; Yakutat, Cape Suckling - Yakataga ("W" grounds), Portlock Bank, and Chirikof Island in Alaska. Other reported spawning locations include Goose Islands, Hecate Strait, and Rose Spit in British Columbia, Cape Ommaney, Cape Spencer, and Cape St. Elias in Alaska, and the 200 m edge in the Bering Sea from Unimak Pass to the Pribilof Islands (St-Pierre 1984). In addition to these major grounds, there is reason to conclude that spawning is widespread and occurs in many areas, although not in as dense concentrations as those mentioned above. Evidence to support this conclusion is based on the widespread distribution of sexually mature halibut during the winter months as indicated by research and commercial fishing.

The number of eggs produced by a female is related to its size. A 31 kg[1] female will produce about 500,000 eggs, whereas a female over 151 kg may produce 4 million eggs. The age of 50% maturity is 8 years old for males and 12 years old for females (St-Pierre 1984). The free-floating eggs are about 3 mm in diameter when released and fertilization takes place externally. Developing ova generally are found at depths of 75 to 185 meters, but occur as deep as 500 meters. The temperature at which eggs are found varies from 2.3 to 9.7 degrees Celsius (St-Pierre 1984). The eggs hatch after 15 to 20 days at 5-6 degrees Celsius, and more quickly in warmer water (12 to 14 days at 7-8 degrees Celsius) (McFarlane et al., 1991). The larvae have a greater specific gravity than the eggs and are found below 200 m (St-Pierre 1989), drifting passively in the deep ocean currents. As the larvae grow, their specific gravity decreases and they gradually move towards the surface and drift to shallower waters on the continental shelf. Postlarvae in North American waters may be transported many hundreds of miles by the Alaskan Stream which flows counter-clockwise in the Gulf of Alaska and westward along the Alaska Peninsula and Aleutian Islands. Some of the larvae are carried into the Bering Sea.

Larvae begin life in an upright position with an eye on each side of the head. When the larvae are 2.5 cm long, the left eye moves over the snout to the right side of the head and pigmentation on the left side

[1]All weights in this report are head-on round weight.

fades. When the young fish are about 6 months old and measure 3.5 cm, they have the characteristic adult form and settle to the bottom in shallow inshore areas (Thompson and VanCleve, 1936).

To counter the egg drift with ocean currents in a counter-clockwise direction, the young halibut migrate in a clockwise direction (IPHC 1987). One and two-year-old Pacific halibut are commonly found in inshore areas of central and western Alaska, but are virtually missing from southeast Alaska and British Columbia. They tend to move further offshore at age 2 or 3-years old and can be found off southeast Alaska and British Columbia by age 4 and older. IPHC tagging studies suggest that there is some intermixing of halibut between the North American and Asian populations, but the extent is not known (IPHC 1978).

By the time Pacific halibut are about 8 years old and measure approximately 82 cm, most of the extensive counter-migration to balance egg and larval drift has taken place. However, adult halibut migrate annually, moving to deeper depths on the edge of the continental shelf during the winter for spawning, and into shallow coastal waters in the summer months for feeding (St-Pierre 1984). Although halibut have been caught as deep as 550 meters, they are most often caught between 25 and 275 meters (Table 1).

Adult halibut are long-lived and the largest of all flatfish. The oldest halibut on record to date was 55 years old[2]. Documented weights of up to 303 kg exist; however, few males reach 48 kg and nearly all halibut over 60 kg are females (IPHC 1987).

<u>Removals from the population</u>

The IPHC takes into account all removals of halibut from the North Pacific and Bering Sea within the Exclusive Economic Zones of the U.S. and Canada. Fishing for halibut does occur off the coasts of Japan and Russia, but those removals are not included in the IPHC population assessment.

The IPHC stock assessment is based on biological and fishery data obtained through port sampling, IPHC and National Marine Fisheries Service surveys, and special projects. Since the 1930s, biologists have collected lengths, otoliths for aging and catch per unit of effort data. More recently, IPHC surveys have also collected data on gender composition and maturity. Logbook information is supplied by the fishers either through interviews by IPHC staff in the landing ports or via mail post-season.

In North America, Pacific halibut is removed in a number of ways from the population; targeted commercially, for sport, for personal use, as bycatch in other commercial fisheries, as waste from the halibut fishery, and natural mortality (the IPHC uses a natural mortality rate of 0.2). In 1996, an estimated 42,336 metric tons of directed and non-directed catch was removed from the population (Sullivan and Parma, Unpub. [1997]).

The directed commercial fishery is conducted by hook and line gear only. Fish begin recruiting to this gear type at approximately 60 cm in length, but the commercial minimum size limit is 82 cm. The fishery takes place from March to November ranging from shallow inshore waters to as deep as 275 meters along the continental shelf (Figures 2-10). The directed catch consists of individuals chiefly from 7 to 121 kg. The average size in the commercial catch in 1996 was between 9 and 20 kg depending on the area caught, and the average age was 12 years old (Forsberg, J., Unpub [1997]).

[2] Pers. comm., Forsberg, J.E. IPHC

Today's commercial fishing fleet is diverse, using various types of longline gear and strategies to obtain their quarry. Both Alaska and British Columbia have implemented an individual quota (IQ) system, which enables a vessel to fish anytime between March and November. The U.S. West Coast fishery continues to use short, 10 hour seasons and fishing period limits to manage the fishery.

Interception of juvenile halibut (~30 cm and greater) often occurs in trawl fisheries targeting other groundfish species (such as rock sole, pollock, yellowfin sole, and Pacific cod). Incidental catch of halibut also occurs in groundfish hook and line and pot fisheries. Regulations in both Canada and U.S. currently dictate that all halibut caught incidentally must be discarded regardless of whether the fish is living or dead. These fisheries take place throughout the range of halibut and throughout most of the year. The total mortality of halibut since 1990 has averaged 10,323 metric tons per year (Williams, G.H. Unpub [1997].

Trophic Information

Adult halibut are only rarely found as prey of other fish, and mortality on halibut by marine mammals seems low (Best and St-Pierre, 1986). The size, active nature, and bottom dwelling habits make halibut less vulnerable to predation than other species. However, the juvenile fish are much more vulnerable and are preyed upon by larger groundfish such as Pacific cod.

Halibut are opportunistic, carnivorous feeders. In larval halibut, nutrition is derived from a yolk sac until it is absorbed during the early postlarval stage, about 2 months after hatching. The young fish then begin feeding on zooplankton. Halibut 1 to 3 years old are usually less than 30 cm in length and feed on small shrimp, crab, and fish (Best and Hardman, 1982). As halibut increase in size, fish become a more important part of the diet. They are both benthic and pelagic feeders. The species of fish frequently observed in stomachs of large halibut include cod, sablefish, pollock, rockfish, sculpins, turbot, other flatfish, sand lance, and herring (Best and St-Pierre, 1986; Brodeur and Livingston, 1988). Octopus, crabs, clams, and occasional smaller halibut also contribute to their diet although Pacific halibut do not appear to be a primary predator of these species.

References

Best, E.A. and W. H. Hardman. 1982. Juvenile halibut surveys, 1973-1980. IPHC Technical Report 20. 38 p.

Best, E.A. and G. St-Pierre. 1986. Pacific halibut as predator and prey. IPHC Technical Report 21. 27 p.

Brodeur, R.D. and P.A. Livingston. 1988. Food habits and diet overlap of various eastern Bering Sea fishes. NOAA Tech. Memo NMFS F/NWC - 127.

Forsberg, J.E.. Unpub. [1997]. Age Composition and Size at Age of the Commercial Fishery for 1996. IPHC Report of Assessment and Research Activities 1996. 75-77.

International Pacific Halibut Commission. 1978. IPHC Annual Report 1977. 39 p.

________. 1987. The Pacific Halibut: Biology, Fishery and Management. IPHC Technical Report 22. 59 p.

McFarlane, G.A., J.O.T. Jensen, W.T. Andrews, and E.P. Groot. 1991. Egg and Yolk Sac Larval Development of Pacific halibut (*Hippoglossus stenolepis*). IPHC Technical Report 24. 22 p.

Sullivan, P.J. and A.M. Parma. Unpub [1997]. Population Assessment, 1996. IPHC Report of Assessment and Research Activities 1996. 81-104.

St-Pierre, G. 1984. Spawning locations and season for Pacific halibut. IPHC Scientific Report 70. 46 p.

St-Pierre, G. 1989. Recent Studies of Pacific halibut postlarvae in the Gulf of Alaska and Eastern Bering Sea. IPHC Scientific Report 73. 31 p.

Thompson, W. F. and R. VanCleve. 1936. Life History of the Pacific halibut. Int. Fisheries Comm. Report Number 9. 184 p.

Williams, G.H.. Unpub [1997]. Incidental Catch and Mortality of Pacific Halibut: 1962-1996. IPHC Report of Assessment and Research Activities 1996. 189-198.

Table 8.1 Summary of habitat information for Pacific halibut.

Life stage	Age	Diet	Season	Location	Water column	Bottom type	Oceanographic features
Eggs level 0	0-20 days	n/a	November - March	Continental shelf edge - pelagic	75-185 m (found as deep as 500 m)		2-10ºC
Larvae level 0	20 days - 2 months	yolk sac	December - May	Continental shelf edge - pelagic	> 200 m		
Post larvae level 0	2 - 6 months	zoo-plankton	January - August	Continental shelf - pelagic	0-200 m		
Juveniles level 1	6 months - 7 years	small crustaceans and fish	Year round	Continental shelf - demersal	25-275 m	Rock, sand, mud, gravel	Prefer 3-8ºC
Adults level 2	8+ years	pelagic and demersal fish and crustaceans	(spawning) Nov. - Mar. (not spawning) Mar. -Nov.	(spawning) Cont. shelf edge - demersal (not spawning) Cont. shelf - demersal	(spawning) 185-460 m (not spawning) 25-275 m	Rock, sand, mud, gravel	Prefer 3-8ºC

See table of contents for the following figures:

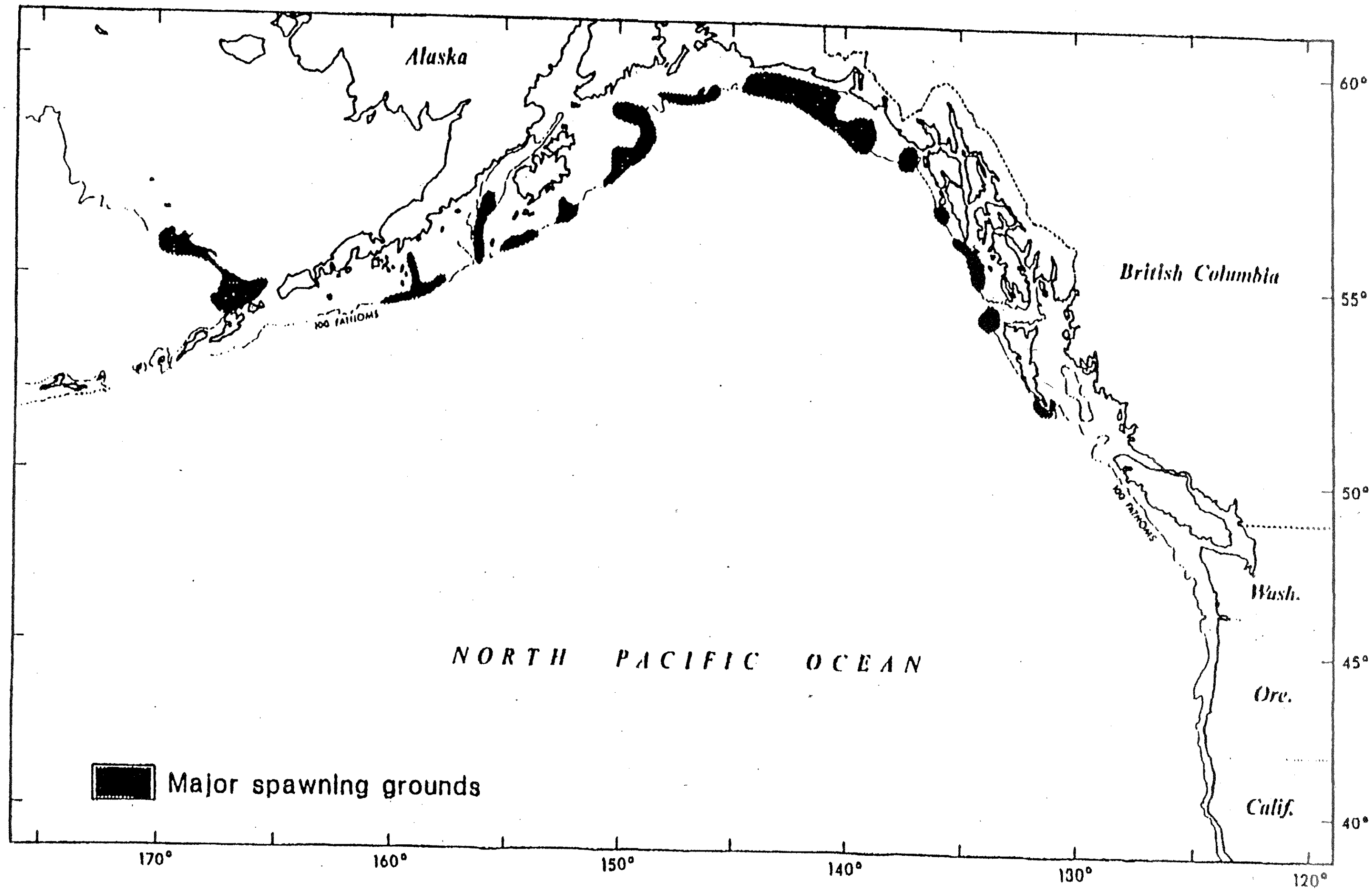


Figure 1. **Major spawning grounds for Pacific halibut.**

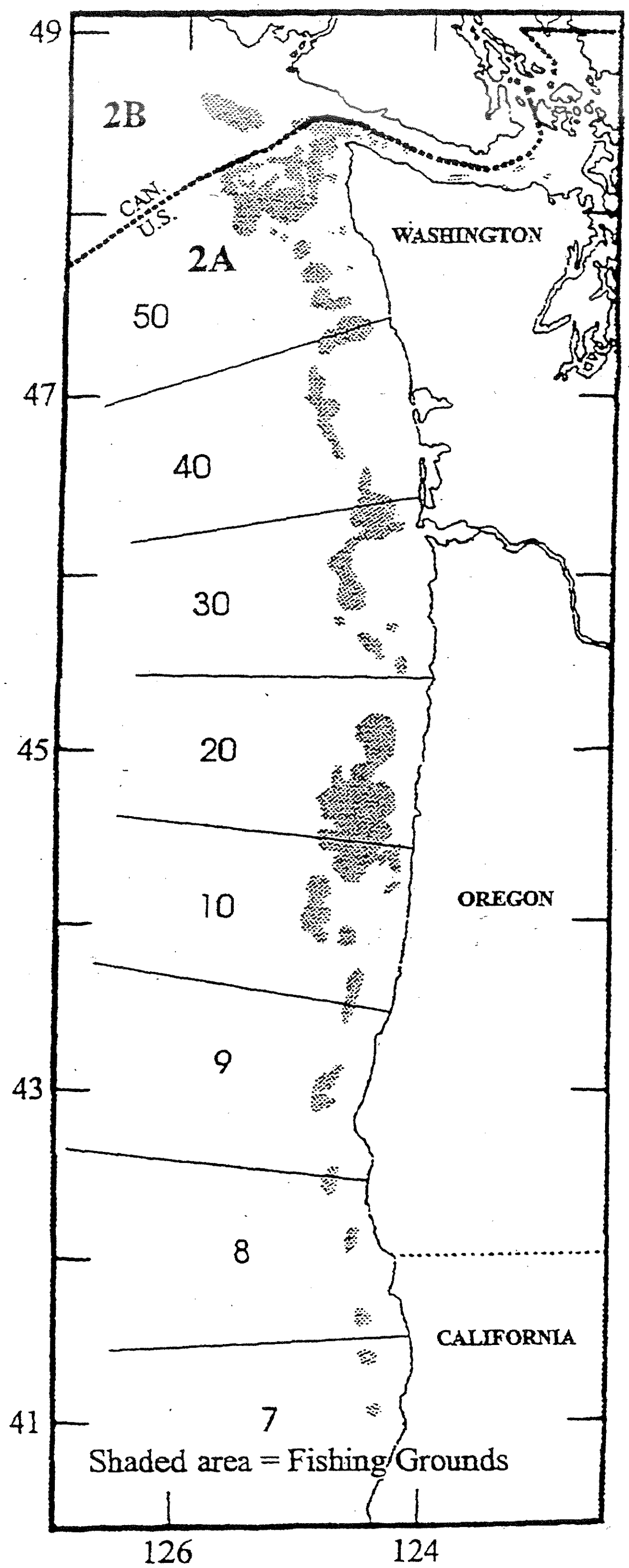


Figure 2. **Pacific halibut fishing grounds in California, Oregon, and Washington.**

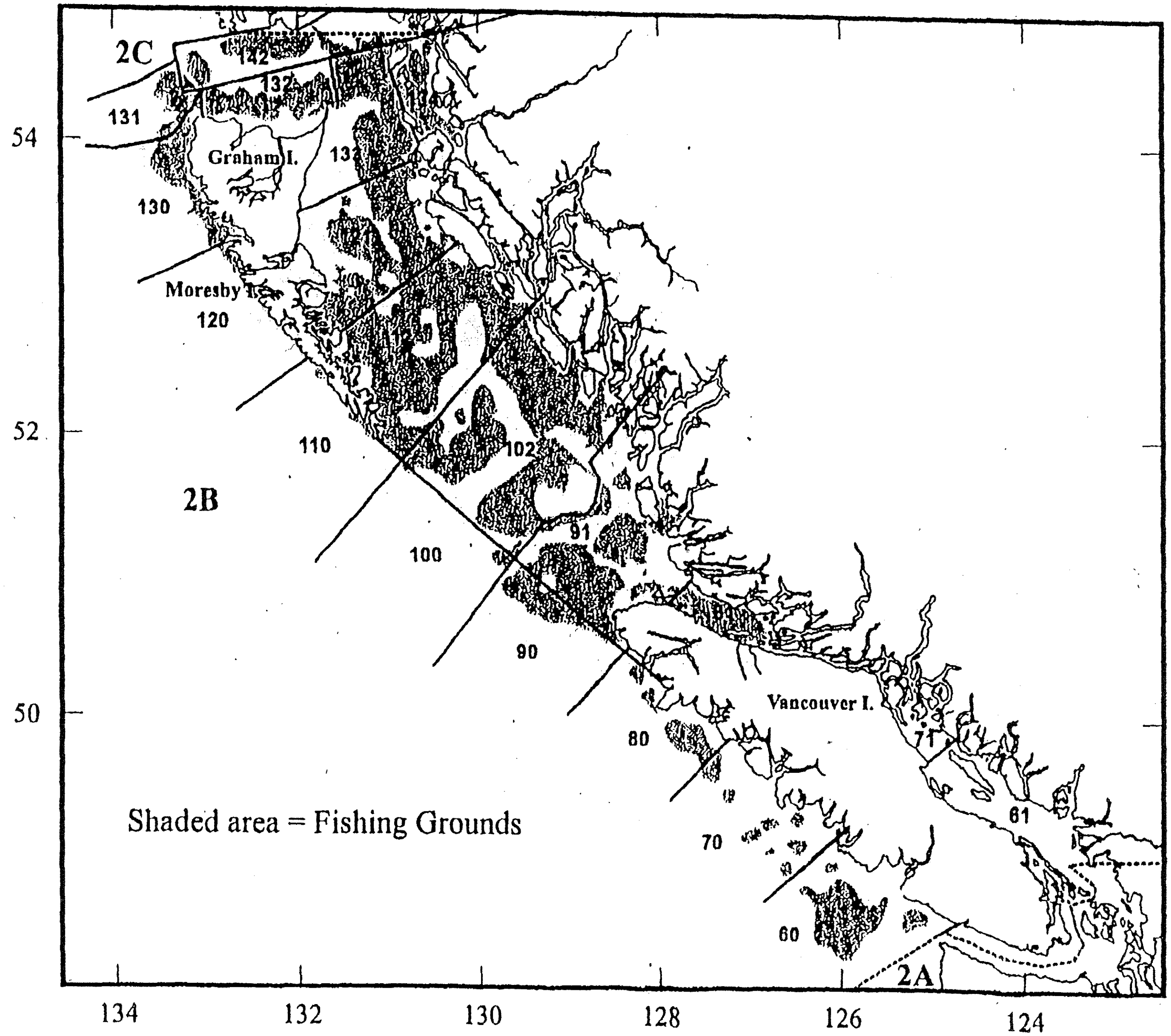


Figure 3. Pacific halibut fishing grounds in British Columbia.

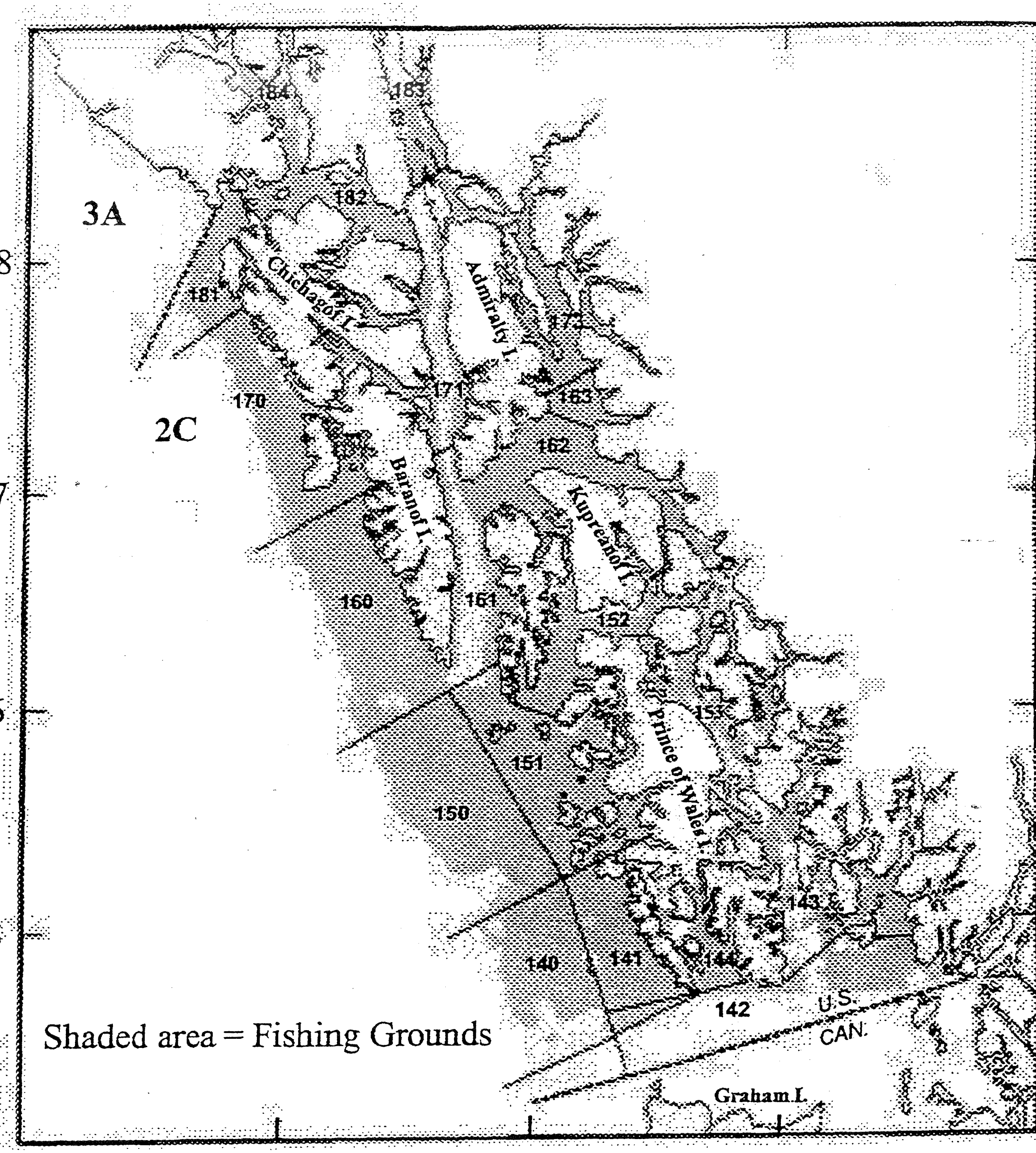


Figure 4. Pacific halibut fishing grounds in Southeast Alaska.

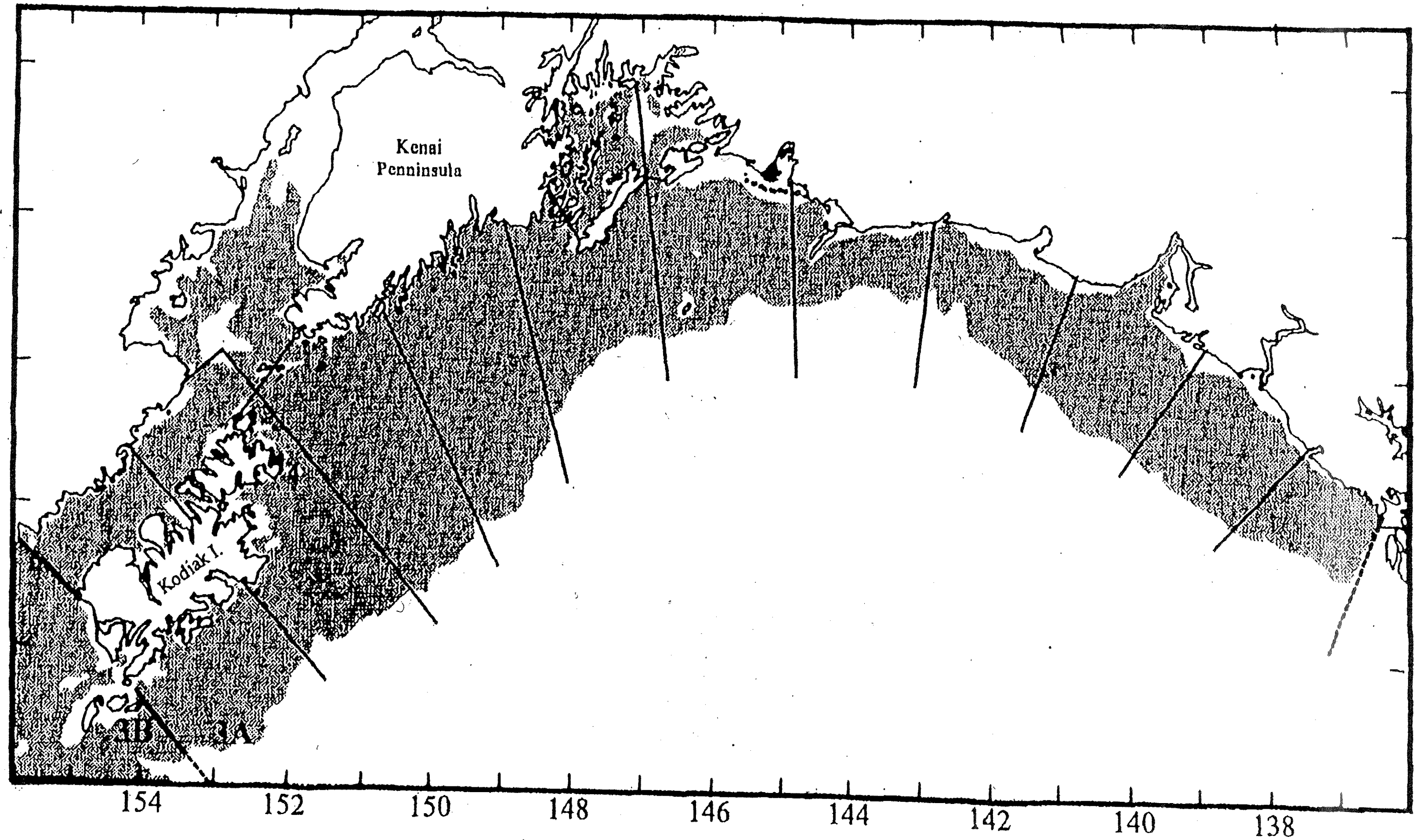


Figure 5. **Pacific halibut fishing grounds in the Central Gulf of Alaska.**

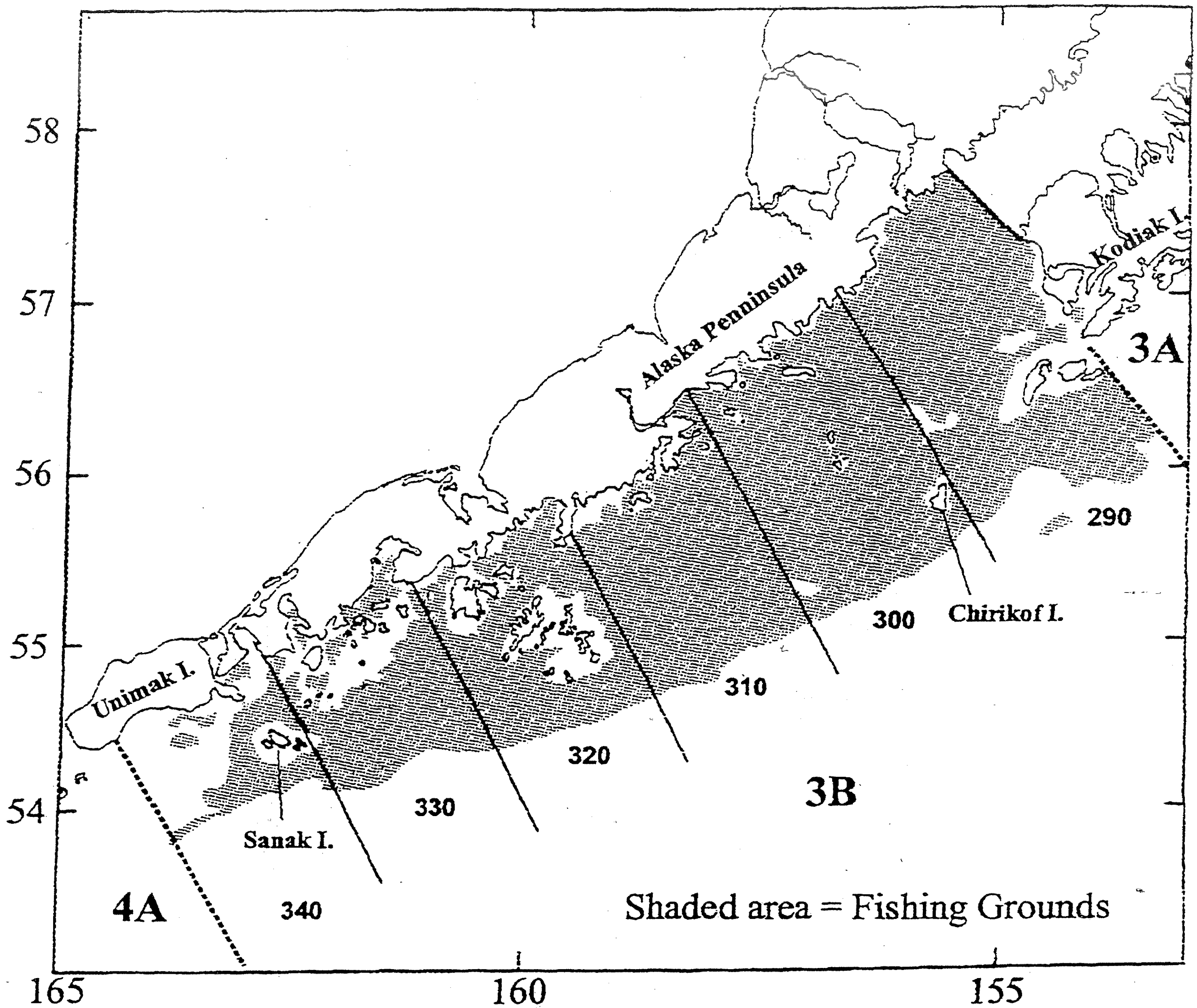


Figure 6. **Pacific halibut fishing grounds in the Western Gulf of Alaska.**

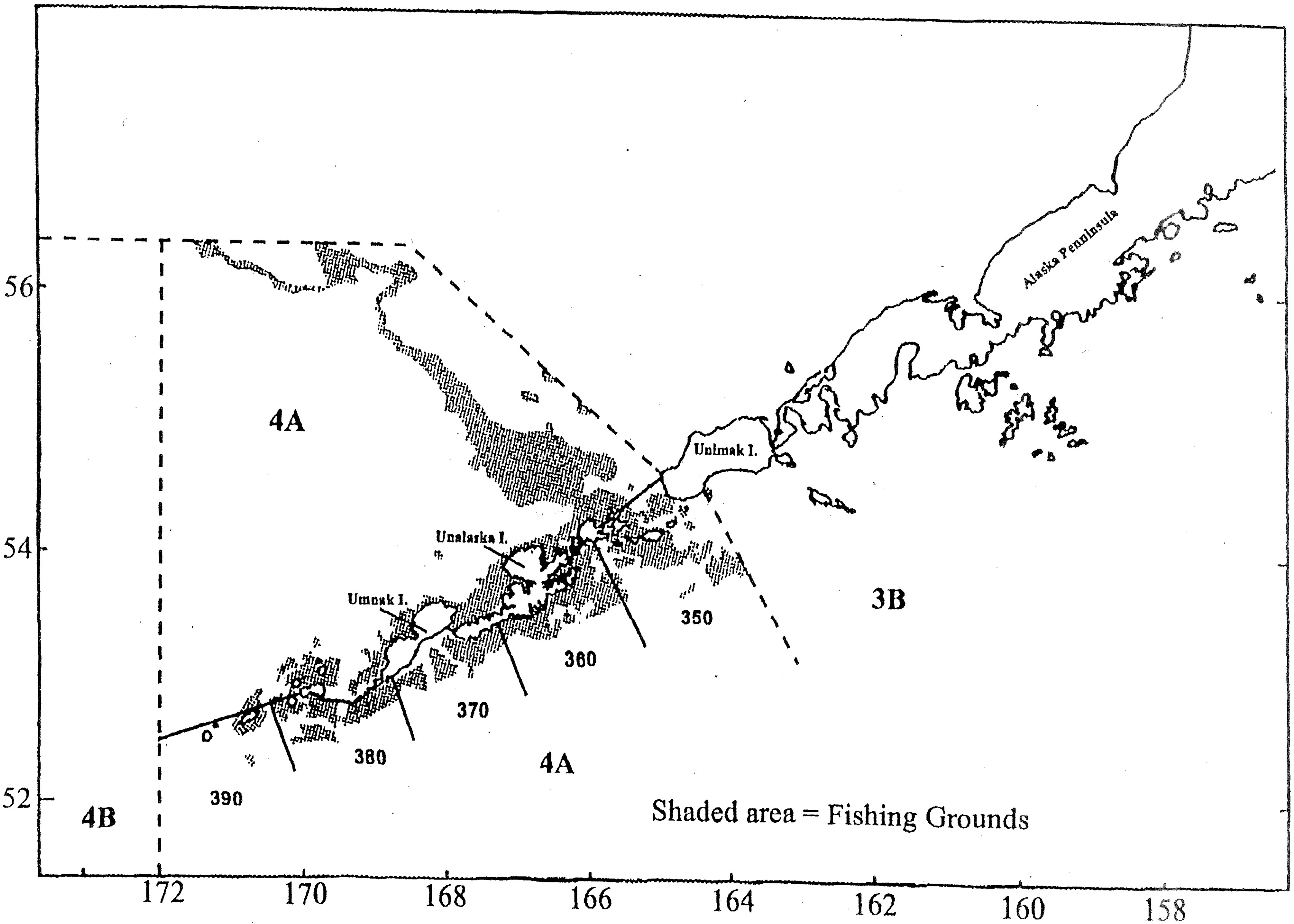


Figure 7. **Pacific halibut fishing grounds in the Western Gulf of Alaska and Southeastern Bering Sea.**

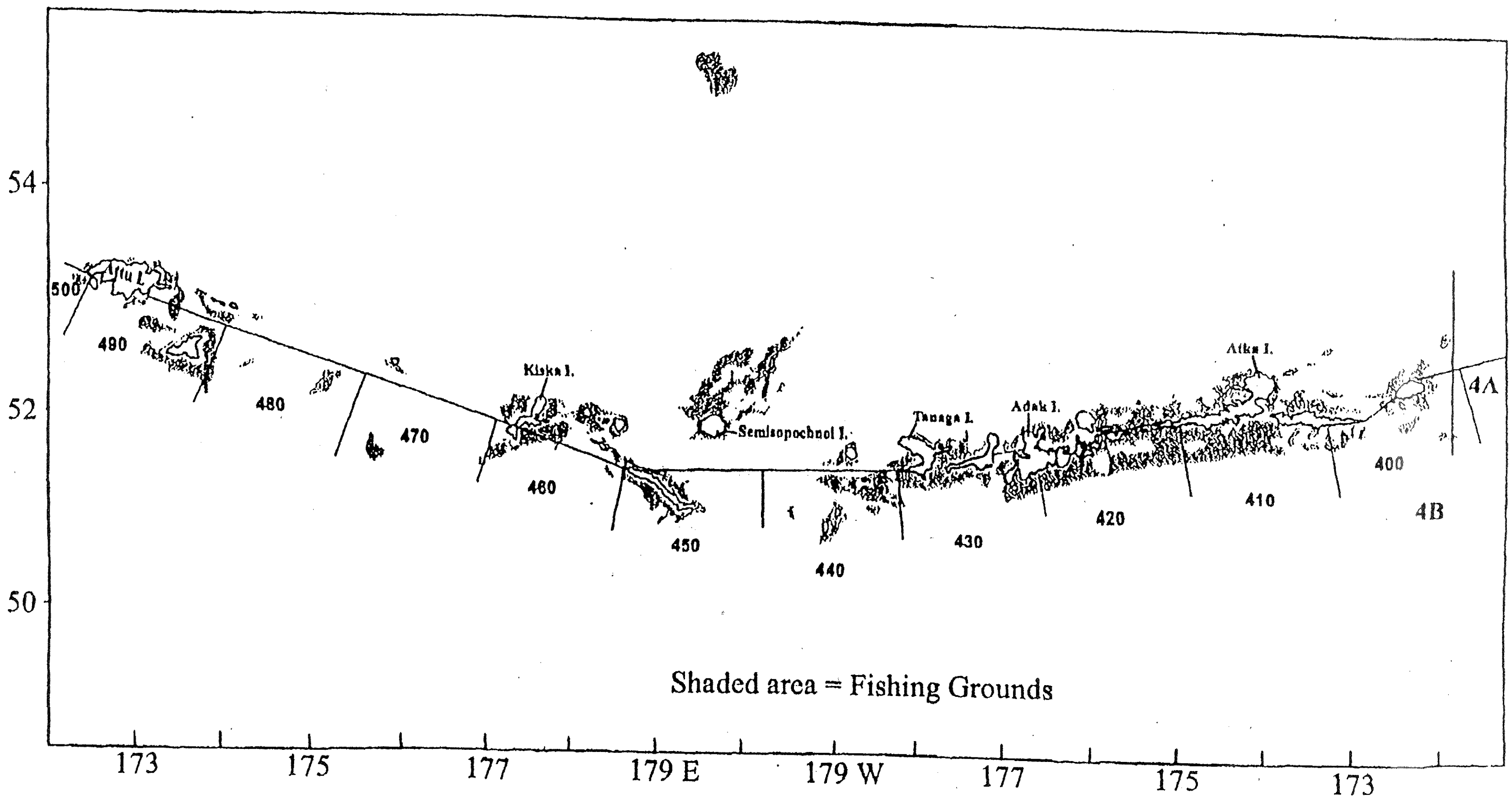


Figure 8. **Pacific halibut fishing grounds in the Aleutian Islands.**

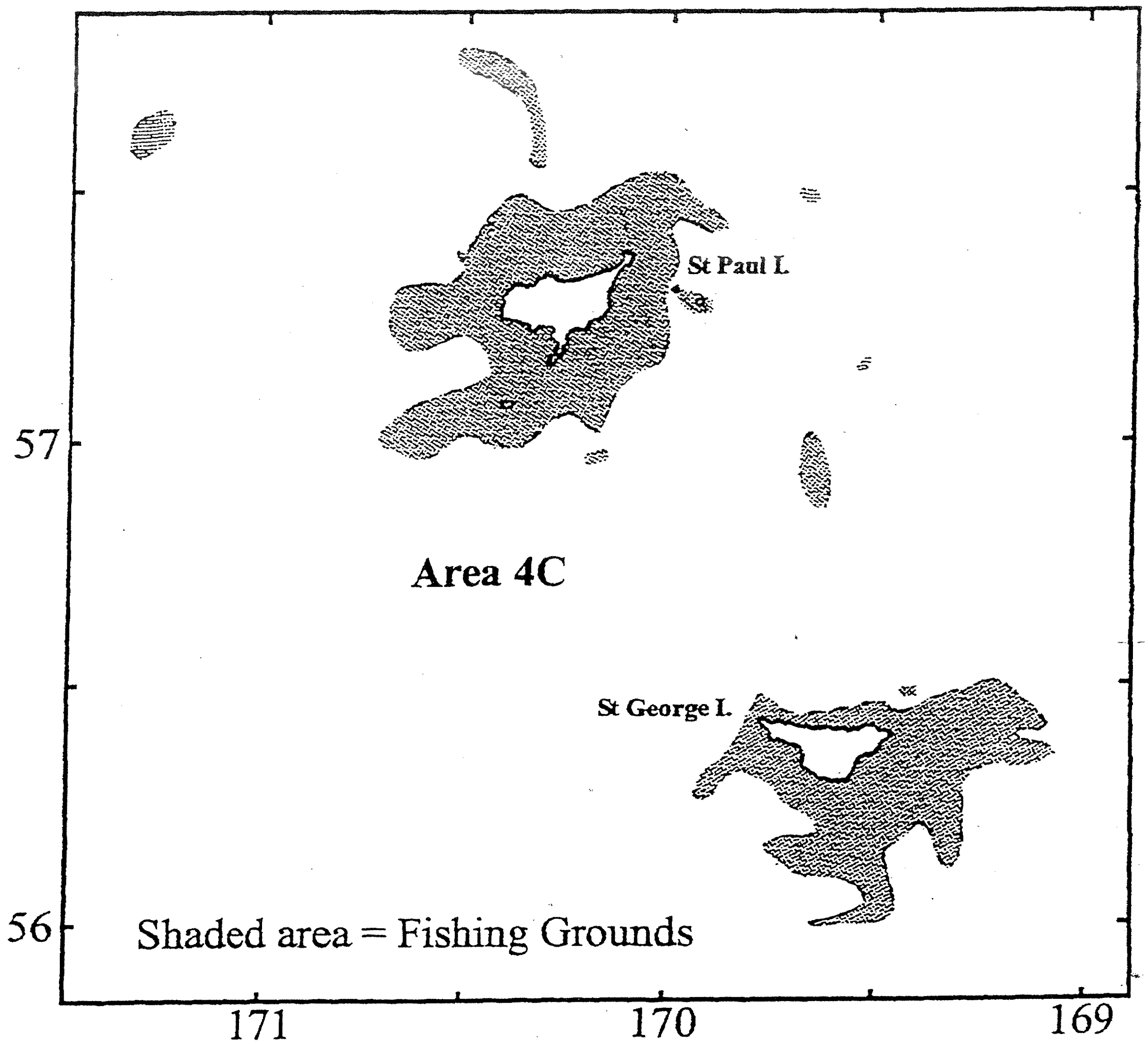


Figure 9. **Pacific halibut fishing grounds in the Pribilof Islands.**

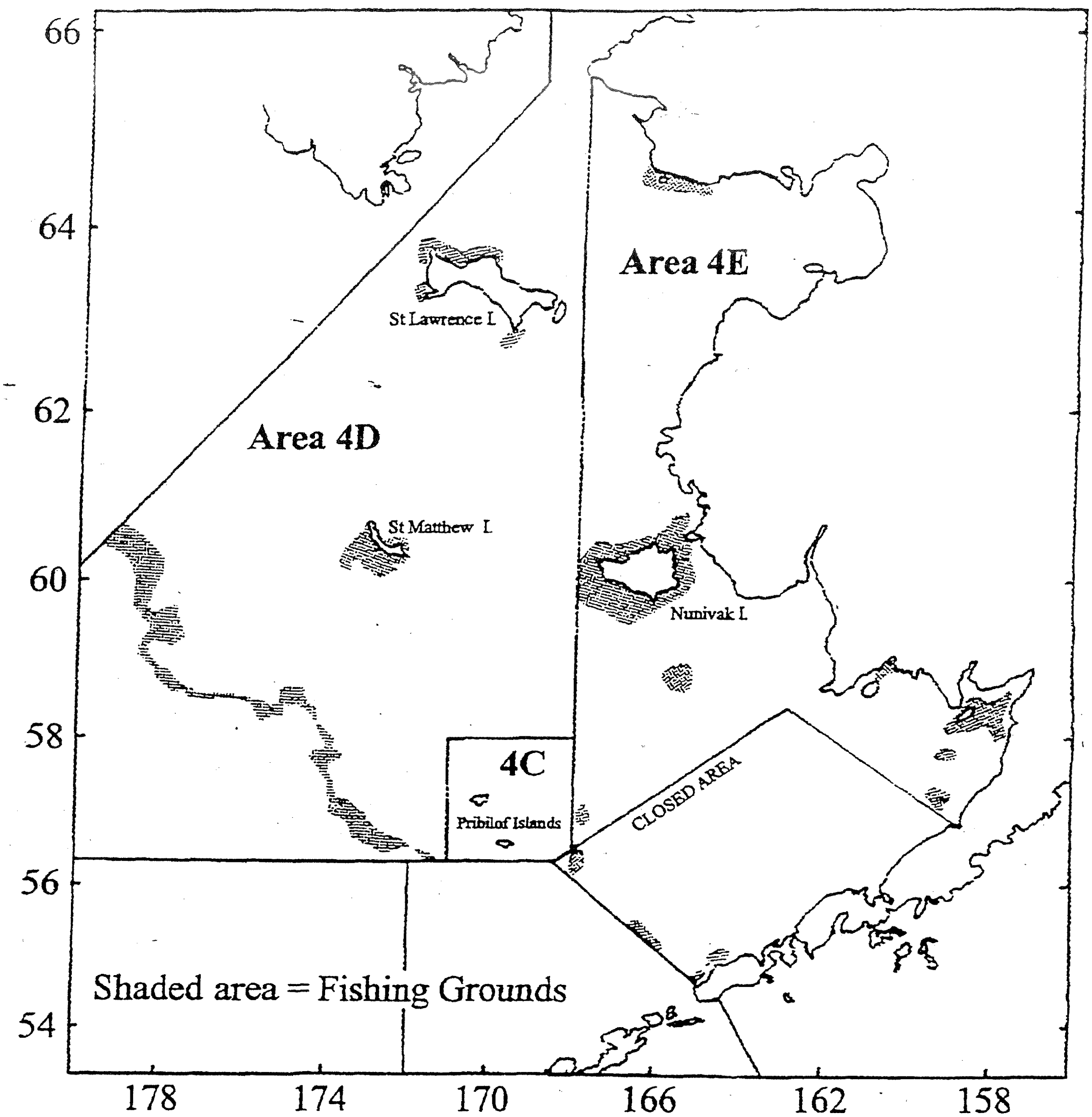


Figure 10. Pacific halibut fishing grounds in the northern Bering Sea.

8.2 Pacific Herring

Habitat Description for Pacific Herring
<u>Clupea pallasi</u>

<u>Management Plan and Area(s)</u> Groundfish, BSAI (prohibited species)

<u>Life History and General Distribution</u> In North America, Pacific herring are found from San Diego Bay, California, to Cape Bathurst in the Beaufort Sea (Hart 1973). In Alaska, herring can be found at some time of the year along most of the coastline from Dixon Entrance in Southeastern Alaska to Kotzebue. Pacific herring spawn on submerged vegetation in shallow coastal intertidal and subtidal areas, although substantial spawning occurs on rock substrates in the northern Bering Sea where vegetation is sparse. Spawning is first observed in the southeastern archipelago in mid-march, with spawning in Bering Sea coastal areas occurring during May and June. The eggs are adhesive and cling to nearshore vegetation, often deposited in layers that are several eggs thick. After spawning, adult herring move to offshore feeding areas. The largest concentrations of herring in the Bering Sea spawn along the north shore of Bristol Bay. Following spawning these herring move clockwise along the Alaskan Peninsula, reaching the Unimak Pass area by mid-summer (Funk 1990). Later in the summer these herring move to wintering areas to the north in the general vicinity of the Pribilof Islands (Shaboneev 1968). Smaller concentrations of herring spawn to the north up the Bering Sea coast, but the offshore feeding and wintering grounds for these herring at not well known.

<u>Fishery (e.g., gear types, age at 50% recruitment, when/where conducted, bycatch)</u> Purse seine and gillnet fisheries harvest herring for sac roe on the inshore spawning grounds, just prior to spawning. Age of 50% recruitment in the purse seine fisheries is estimated to be 5, in the gillnet fisheries age 7. In the vicinity of the village of Togiak along northern Bristol Bay coastline, a small locally-based fishery hand picks 170 metric tons of herring spawn on kelp (primarily *Fucus* sp.) annually. A small purse seine fishery for food and bait herring occurs during the summer in the vicinity of Dutch Harbor. Herring are taken as bycatch in trawl fisheries, primarily for pollock, near Unimak pass during the summer months.

<u>Relevant Trophic Information</u> Pacific herring are opportunistic planktivores, and are themselves preyed on by most piscivorous fish and marine mammals.

<u>Potential gear impacts on the habitats of this or other species</u> Except during the spawning period, Pacific herring occur pelagically and are not likely to be impacted by fishing gear impacts on habitat. A small (170 m.t.), controlled amount of spawning substrate is removed annually during the directed spawn on kelp fishery in Bristol Bay. Purse seine or gillnet gear occasionally scrapes the bottom in areas where some spawning substrate is removed. However fishermen generally try to avoid much contact with rocky, kelp-containing substrates to preclude loss or damage to fishing gear.

<u>What is the approximate upper size limit of juvenile fish:</u> 23 cm.

<u>Habitat and Biological Associations</u>

<u>Egg/Spawning:</u> In the Bering Sea, spawning occurs on rocky headlands or in shallow lagoons and bays. Eggs are deposited both subtidally and intertidally on aquatic vegetation. Predominant vegetative types along the Bering Sea coastline are eelgrass (*Zostera spp*), rockweed (*Fucus spp*.), and ribbon kelp (<u>*Laminaria*</u> *spp*) (Barton 1978). Herring north of Norton Sound spawn in brackish bays and estuaries (Barton 1978). Spawning activity is related to water temperatures and occurs soon after water has become ice-free. Water temperatures on Bering Sea spawning grounds between Norton Sound and Bristol Bay have ranged between 5.6° and

11.7°C (Barton 1979). Optimum temperature for egg development in the laboratory is from 5° to 9°C. Below 5°C, eggs die (Alderdice and Velsen 1971). Eggs take to 10 to 21 days to hatch, depending on the water temperature (Wespestad and Barton 1981). In Bristol Bay, at temperatures to 8° to 11°C, 13 to 14 days are required for hatching (Barton 1979).

Larvae: Newly hatched larvae are about 8 mm in size. Larvae will grow to 30 mm in 6 to 10 weeks and begin to metamorphose into free-swimming juveniles. Larvae are at the mercy of water currents until they develop the ability to swim (Hourston and Haegele 1980). Larvae migrate downwards during the day and to the surface at night, following their planktonic food supply (Hart 1973). Herring larvae and postlarvae feed on ostracods, small copepods and nauplii, small fish larvae, and diatoms (Hart 1973). The first food eaten by larval herring may be limited to relatively small, microscopic planktonic organisms that the larvae must nearly run into to notice and capture. Early food items may be comprised of more than 50% microscopic eggs (Wespestad and Barton 1979). Oceanographic conditions that retain larvae in productive inshore areas is thought to enhance larval survival (Wespestad 1991).

Juveniles: Immature Pacific herring remain offshore and do not participate in the inshore spawning movements of mature adults. The distribution of juvenile herring is not well known. Juveniles consume mostly crustaceans such as copepods, amphipods, cladocerans, decapods, barnacle larvae, and euphasiids. Consumption of some small fish, marine worms, and larval clams has also been documented (Hart 1973). In the western Bering Sea and Kamchatka area in November and December, the diet of juveniles has consisted of medium forms of zooplankton (Chaetognaths, mysids, copepods, and tunicates) (Kachina and Akinova 1972).

Adults: After spawning, herring move to offshore feeding and overwintering areas and are not closely associated with the bottom and likely not affected by bottom substrates. Adults were found to overwinter at depths of from 107 to 137 m in the Bering Sea (Dudnik and Usoltsev 1964). In the Bering Sea, temperature may have the greatest influence on the seasonal distribution of herring (Wespestad and Barton 1981). Dense schools of overwintering adult herring have been found at temperatures of from 2 to 3.5°C in the Bering Sea (Dudnik and Usoltsev 1964). Herring moving from the overwintering grounds in the Bering Sea to spawning grounds have passed through water at subzero temperatures (Wespestad and Barton 1981). Immature herring may occupy less saline waters than adults (Taylor 1964). Juveniles, however, are found in a wide range of salinities in British Columbia, with most concentrations located at 25 parts per thousand (o/oo) (Hourston 1959). Herring eggs and fry were found in Imuruk Basin near Port Clarence, Alaska, in water of 4 o/oo salinity (Barton 1978). Immature fish in the Bering Sea exhibit greater tolerance or preference for colder, less saline areas on their overwintering grounds on the continental shelf than do adult fish (Wespestad and Barton 1981). The timing of spawning in the western Bering Sea is related to winter and spring water temperatures, with early maturation occurring in warm years and delayed development in colder years (Prokhorov 1968). In Bristol Bay and Port Heiden, herring appeared on the spawning grounds when temperatures reached 6°C.

In the eastern Bering Sea, August diets of adults were comprised of 84% euphausiids, 8% fish fry, 6% calanoid copepods, 2% gammarid amphipods; fish fry, in order of importance, were walleye pollock, sandlance, capelin, and smelt. During spring months, food items were mainly Themisto (amphipoda) and Sagitta (chaetognath). After spawning (eastern Bering Sea), adults preferred euphausiids, copepods (Calanus spp.), and arrow worms (Sagitta spp.) (Dudnik and Usoltsev 1964). In demersal areas, stomach contents included polychaete worms, bivalve molluscs, amphipods, copepods, juvenile fish, and detritus (Kachina and Akinova 1972), Barton (1978) found cladocerans, flatworms (Platyhelminthes), copepods, and cirripeds in herring captured during spring months. Rather than exhibiting a preference for certain food items, adult herring feed opportunistically on any large organisms predominating among the plankton in a given area (Kaganovskii 1955).

Herring Literature

Alderdice, D.F., and F.P. Velsen. 1971. Some effects of salinity and temperature on early development of Pacific herring. J. Fish. Res. Bd. Canada 18:545-562

Barton, L.H. 1978. Finfish resource surveys in Norton Sound and Kotzebue Sound. OCSEAP, final report (March 1976-September 1978). Alaska Department of Fish and Game, Commercial Fisheries Division, Anchorage.

Barton, L.H. 1979. Assessment of spawning herring and capelin stocks at selected coastal areas in the eastern Bering Sea. Final Report to the North Pacific Fishery Management Council, Contract 78-5.

Dudnik, Y.J., and E.A. Usoltsez. 1964. The herring of the eastern part of the Bering Sea. Pages 225-229 in P.A. Moiseev, ed. Soviet Fisheries investigations in the northeast Pacific. Part 2. Transl. Israel Prog. Sci. Transl. Jerusalem, 1968.

Funk, F.C. 1990. Migration of eastern Bering Sea herring, as inferred from 1983-1988 joint venture and foreign trawl bycatch rates. Regional Information Report No. 5J90-04, Alaska Department of Fish and Game, Juneau.

Hart, J.L. l973. Pacific fishes of Canada. Fish. Res. Board Can., Bull. l80. 740 p.

Hourston, H.S. and C.W. Haegele. 1980. Herring on Canada's Pacific coast. Can. Spec. Pub. Fish. Aquatic Sci. 48:23.

Kachina, T.F., and R.Y. Akinova. 1972. The biology of the Korfo-Koraginski herring in the first year of life. Izv. Tikhokean. Nauchnoissled, Inst. Rybn. Khoz. Okeanogra. Cited in Wespestad and Barton 1979.

Kaganovskii, A.G. 1955. Basic traits of behavior of pelagic fishes and methods of scouting and forecasting them in far eastern waters. Akad. Nauk. SSR., Tr. Soveshch. Ikhtiol. Kom. 5 (Trans. Nat. Mar. Fish. Serv. Biol. Lab. Honolulu).

North Pacific Fishery Management Council (NPFMC) 1983. Bering-Chukchi Sea Herring Fishery Management Plan, final draft. North Pacific Fishery Management Council, Anchorage.

North Pacific Fishery Management Council (NPFMC) 1991. Environmental Assessment/Regulatory Impact Review/Initial Regulatory Flexibility Analysis for Amendment 16A to the Bering Sea/Aleutians Groundfish Fishery Management Plan. North Pacific Fishery Management Council, Anchorage.

Prokhorov, V.G. 1968. Winter period of life of herring in the Bering Sea. Proceedings of the Pacific Scientific Research of the Fisheries and Oceanography 64:329-338. In Russian. Transl. 1970, Fish. Res. Bd. Can. Transl. Ser. 1433.

Rumyantsev, A.I., and M.A. Darda. 1970. Summer herring in the eastern Bering Sea, pages 409-441. In P.A. Moiseev (ed.), Soviet fisheries investigations in the northeastern Pacific, Part V. (In Russian, Translated 1972. Israel Program Scientific Translations, available from U.S. Department of Commerce National Technical Information Service, Springfield, Virginia).

Shaboneev I.E. 1968. Biology and fishing of herring in the eastern part of the Bering Sea. Pages 130-154 in P.A. Moiseev (ed.), Soviet fisheries investigations in the northeastern Pacific, Part V. (In Russian, Translated 1972. Israel Program Scientific Translations, available from U.S. Dept. of Commerce National Technical Information Service, Springfield, Virginia, as TT67-51206).

Warner, I.M. and P. Shafford. 1977. Forage fish spawning surveys - southern Bering Sea. Alaska Marine Environmental Assessment Project, project completion report. 111 pages.

Wespestad, V.G. 1991. Pacific herring population dynamics, early life history, and recruitmetn variation relative to eastern Bering Sea oceanographic factors. Ph.D. Dissertation, University of Washington, Seattle.

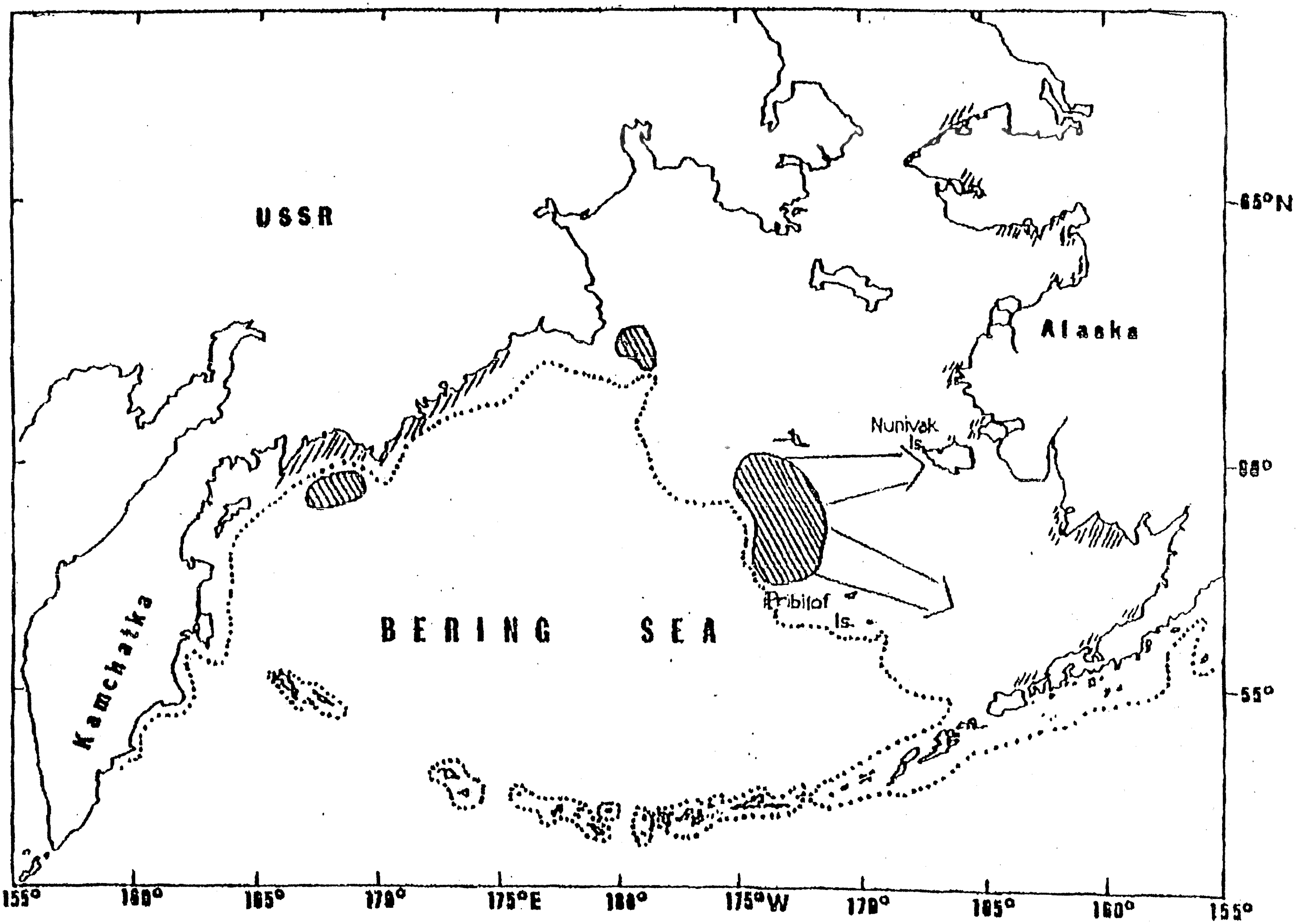
Wespestad, V., and L. Barton. 1981. Distribution and migration and status of Pacific herring, p. 509-525. In D.W. Hood, and J.A. Calder (eds.) The eastern Bering Sea shelf: oceanography and resources. Volume I, U.S. Government Printing Office, Washington D.C.

See table of contents for the following:

Location of the spawning and winter grounds (oval areas) of main eastern and western Bering Sea herring stocks and routes of migration of eastern stocks to spawning areas.

SPECIES: Pacific Herring

Stage - EFH Level	Duration or Age	Diet/Prey	Season/Time	Location	Water Column	Bottom Type	Oceano-graphic Features	Other
Eggs level 2	10-21 days	NA	Spring	BCH	D	K, SAV, R		
Larvae level 0	2-3 months	Small zooplankton, eggs	Spring/ Summer	Bay ICS	P	NA	G	
Juveniles level 0	1-5 years	Opportunistic zooplanktivore	All year	ICS MCS OCS	P	NA	F, E	
Adults level 2	5+ years	Opportunistic zooplanktivore	Spawning (May-June) Other	BCH Bay Bay ICS MCS OCS	P P	NA NA	F, E	



Location of the spawning and winter grounds (oval areas) of main eastern and western Bering Sea herring stocks and routes of migration of eastern stocks to spawning areas.

8.3 GOA Crab Species

Habitat Description for GOA Red King Crab

Paralithodes camtschaticus

Management Plan and Area(s)

No federal fishery management plan exists for the commercial king, Tanner and Dungeness crab fisheries in the Gulf of Alaska

Life History and General Distribution

Red king crab (*Paralithodes camtshaticus*) is widely distributed throughout the Bering Sea and Aleutian Islands, Gulf of Alaska, Sea of Okhotsk, and along the Kamchatka shelf. On the coast of North America it is found from Point Barrow, Alaska, to the Queen Charlotte Islands and waters adjacent to mainland northern British Columbia. Red king crab occupy depths from the intertidal region (young-of-the-year crabs) to 366 meters. Red king crab molt several times per year through age 3 after which molting is annual. At larger sizes, king crab may molt less frequently than annually as growth slows. Females grow more slowly and do not attain the size of males. In the northeastern Gulf of Alaska, fifty percent maturity is attained by females at 106 mm (about 6 yrs.). Natural mortality of adult red king crab males increases with size and has been estimated to reach about 25 percent per year (M=0.3) in crab greater than 135 mm carapace length, owing to old age, disease, and predation.

Fishery

Red king crab fisheries have been prosecuted in the Gulf of Alaska since 1954. The gear has evolved to include side loading mesh covered pots approximately 6 to 8 feet square and top loading pyramid or conical style gear. Discrete populations are found in the Alaska Peninsula, Kodiak, Cook Inlet, Prince William Sound and Southeastern Management areas.

Historically, the red king crab fishery has been Alaska's top shellfish fishery. Since the mid-1950's fishermen have harvested over 1 billion pounds of red king crab from Gulf of Alaska waters. The peak harvest came in 1965 when approximately 113 million pounds were landed from the five management areas. The Kodiak area was the major contributor at 94 million pounds. A near peak harvest occurred in the 1980/81 season, but three years later the fishery had crashed with the harvest down sixty-fold and all management areas in the Gulf closed completely for the first time.

A long period in which few juvenile king crab survived to adult size preceeded the crash. A combination of overfishing, fish predation on king crab, and a warmer ocean environment were the likely contributing factors for the current low stock size of red king crabs in the Gulf of Alaska. Their populations remain depressed and fisheries have not been open since 1983 with the exception of a small fishery in inside waters of Southeastern Alaska, that has occurred yearly since 1993.

Relevant Trophic Information

Subadult and adult Red King Crabs eat a variety of benthic invertebrates including clams, cockles, snails, barnacles, amphipods, crabs, polychaetes, hydroids, brittle stars, sand dollars, sea urchins and sea stars, and fishes such as Capelin (*Mallotus villosus*), Pacific Sand Lance (*Ammodytes hexapterus*), and Pacific Herring (*Clupea pallasi*). At least some of these fish are probably scavenged. A total of 98 different species were found in the stomachs of Red King Crabs from depths of 50 to 200 meters (164 to 656 feet) in late winter and late spring on the Kodiak Shelf. Red King Crabs in the Okhotsk Sea have been found to prefer echinoderms and barnacles (*Balanus* sp.) just prior to and after molting. These species provide a good source of calcium carbonate which the crabs may need to replace that lost during ecdysis (molting).

The zoeae of the Red King Crab are planktivores, consuming both phytoplankton and zooplankton. Stomach contents of the third and fourth zoeal stages collected in Cook Inlet, Alaska, included diatoms and the larvae of barnacles and the Helmet Crab (*Telmessus cheiragonus*). In the laboratory, the larvae will eat diatoms, crustacean nauplii, copepods, polychaete larvae and rotifers. In Auke Bay, Alaska, the larvae feed during the day at a depth of 5-10 meters (16-33 feet) and not at night. This feeding periodicity is consistent with the reverse diel vertical migration exhibited by Red King Crab larvae in Auke Bay.

Young-of-the-year Red King Crab eat diatoms, foraminiferans (protozoans with calcareous shells), sponge tissue, hydroids, bryozoans, polychaetes, bivalves, gastropods, ostracods, harpacticoid copepods, and sand dollars. In the laboratory postlarval, 1-year-old, and 2-year-old Red King Crabs are cannibalistic. The frequency of cannibalism in 1-year-old crabs depends on the quality of the diet fed to them, crab density and the complexity of the habitat. The frequency of cannibalism in 2-year-old crabs does not depend on crab density or the availability of cover in the laboratory.

A variety of predators consume the various life stages of the Red King Crab. The eggs are preyed upon by at least three species of nemertean worm: *Carcinonemertes regicides*, an undescribed small eyeless species, and *Alaxinus oclairi*. The first two species are the most widespread and abundant nemertean egg predators on Red King Crabs. The gammarid amphipod *Ischyrocerus* sp. also preys on Red King Crab eggs. Walleye pollock (*Theragra chalcogramma*) preys on larval king crab. Yellowfin Sole (*Limanda aspera*) eat large numbers of the glaucothoe stage. Juvenile and adult crabs are preyed upon by Pacific Cod (*Gadus macrocephalus*), Pacific Halibut (*Hippoglossus stenolepis*), sculpins (*Hemilepidotus* and *Myoxocephalus*), the Korean Hair Crab (*Erimacrus isenbeckii*), octopus (*Octopus* sp.) and the Sea Otter (*Enhydra lutris*).

<u>What is the approximate upper size limit of juvenile fish (in cm)?</u>
The size of 50 percent maturity is 10 cm carapace length for female red king crabs from the northeastern Gulf of Alaska.

<u>Provide source (agency, name and phone number, or literature reference) for any possible additional distribution data (do not include AFSC groundfish surveys or fishery observer data)</u>

ADF&G, Petersburg, AK Tim Koeneman, (907) 772-3801
ADF&G, Homer, Charles Trowbridge, (907) 235-8191
ADF&G, Kodiak, Daniel Urban, (907) 486-1840

<u>Habitat and Biological Associations (if known) Narrative</u>

<u>Egg/Spawning</u> See Adults.

<u>Larvae</u> The larval stages consist of a prezoeal stage and four zoeal stages. The first post larval stage is the glaucothoe. The prezoeal stage lasts a few minutes, the zoeal stages each last 2-4 weeks, and the glaucothoe lasts 3-4 weeks. Metamorphosis to the first benthic stage occurs 3-4.5 months after hatching. Red king crab larvae occupy the upper 40-100 meters of the water column depending on the geographical area. The position of the larvae in the water column varies with the time of day. In Auke Bay, Alaska, red king crab larvae

exhibit reverse diel vertical migration. The larvae are most abundant at 5 to 10 meters (16 to 33 feet) during the day and at 30 meters (98 feet) at night. A similar pattern of vertical migration has been observed at Kodiak Island, Alaska. The first and second stage zoeae of red king crab females from Auke Bay tolerate temperature/salinity combinations for short periods that exceed the range to which they are exposed in nature. Stage I zoeae show high survival at temperatures from 0 to 12 C (32 to 54 F) and salinities of 20 to 30 ppt. Stage II zoeae show highest survival at temperatures from 0 to 6 C (32 to 41 F) and salinities of 20 to 30 ppt. Stage I and II zoeae studied in Japan showed similar temperature and salinity tolerances as those at Auke Bay. At Auke Bay, stage II zoeae preferred more saline conditions (29.4 ppt) than did stage I zoeae (27.5 ppt). Zoeae exposed to low salinity water passively sink until they reach higher salinity.

Juveniles Young-of-the-year crab occur at depths of 50 m or less. They are solitary and need high relief habitat or coarse substrate such as boulders, cobble, shell hash, and living substrates such as bryozoans and stalked ascidians. Between the ages of two and four years, there is a decreasing reliance on habitat and a tendency for the crab to form pods consisting of thousands of crabs. Podding generally continues until four years of age (about 6.5 cm), when the crab move to deeper water and join adults in the spring migration to shallow water for spawning. The remainder of the year crab are found in deep water. Juvenile crabs are somewhat more tolerant of reduced salinities than adults (see below).

Adults Adult and older juvenile red king crabs occur on a variety of substrata including rock or gravel (especially nearshore) and mud, sand, shell fragments or mixtures of these substratum types. Mating crabs often occur in areas with kelp (*Alaria*, *Costaria* and *Laminaria*). The kelp can provide cover for the courting pair when the female is soft and vulnerable to predation following molting. Red king crab do not osmoregulate and cannot tolerate low-salinity water. Adults show signs of stress when immersed in sea water of less than about 18 ppt salinity. Red king crabs exhibit seasonal migration. Adult crabs occupy deeper offshore areas in summer. In late fall and early winter the crabs migrate onshore to shallow waters prior to larval hatching, molting of females, mating and egg extrusion which takes place from January through June depending on the geographical area. After this period of reproduction the crabs return to deep water. In southeastern Alaska, red king crab mate when they enter shallower waters (<50 m), generally beginning in January and continuing through June. Males grasp females just prior to female molting, after which the eggs are fertilized and extruded onto the pleopods of the female's abdomen. In the northeastern Gulf of Alaska fecundity ranges from 148,300 to 446,600 eggs for females ranging in carapace length from 128 to 145 mm (5 to 5.7 in). The female red king crab carries the eggs for 11-12 months before they hatch, generally in March through May. Hatching of king crab larvae is temporally synchronized with the spring phytoplankton bloom in southeastern Alaska.

SPECIES: Red king crab, *Paralithodes camtschaticus*

Stage - EFH	Duration or	Diet/Prey	Season/Time	Location	Water	Bottom	Oceanographic	Other
Eggs 1	11- 12 mo	NA	May-April	NA	NA	NA	NA	
Larvae 1	3-4.5 mo	Diatoms, Crustacean larvae	April-August	BAY, ICS	P	NA	F	
Juveniles 1	1 to 5-6 yrs	Diatoms Hydroids Polychaetes Mollusks, Harpacticoid copepods Bryozoans	All year	BCH, BAY ICS	D	SAV (epifauna), R, CB, G	NA	Found among biogenic assemblages (sea onions, tube worms, bryozoans,
Adults 1	10-15 yrs	Mollusks, echinoderms, polychaetes, decapod, crustaceans, Algae, urchins, hydroids, sea stars	Spawning Feb- June	ICS, BAY, BCH	D	S, M, CB, G	CL	

Habitat Description for GOA Blue king crab
Paralithodes platypus

Management Plan and Area(s)

No federal fishery management plan exists for the commercial king, Tanner and Dungeness crab fisheries in the Gulf of Alaska.

Life History and General Distribution

The Blue King Crab ranges discontinuously from Kamchatka to Hokkaido, Japan and from Kotzebue Sound, Alaska, to southeastern Alaska. In the Gulf of Alaska, small populations have been found in Olga Bay at Kodiak Island, Port Wells in Prince William Sound, and Russell Fiord, Glacier Bay, Lynn Canal and Endicott Arm in southeastern Alaska. Blue king crab molt many times as juveniles. In Olga Bay, 50 percent maturity of females is attained at 9.4 cm carapace length, which occurs at about 5 years of age. Blue king crab in Prince William Sound mature at a somewhat smaller size (50 percent maturity at 8.7 cm carapace length for females). Male size at maturity has been found to be 8.7 and 9.3 cm carapace length at Olga Bay and Prince William Sound, respectively. Skip molting occurs with increased probability in males larger than 10 cm carapace length. Larger female blue king crab have a biennial ovarian cycle and a 14 month embryonic period. Unlike red king crab, juvenile blue king crab do not form pods, instead rely on cryptic coloration for protection from predators. Adult male blue king crab occur at an average depth of 70 m and an average temperature of 0.6 degrees C.

Fishery

Blue king fisheries have been prosecuted using mesh covered pots. Landings have been relatively minor with records combined with red king crab for the most part. Some harvest has occurred from the Kodiak, Prince William Sound and Southeastern Alaska areas. The highest recorded catch was 13,000 pounds from Prince William Sound in 1979.

Relevant Trophic Information

Little information is known on the diet or predators of the blue king crab in the Gulf of Alaska. Pacific cod prey on soft-shell blue king crabs, and walleye pollock and yellowfin sole prey on the glaucothoe in the Bering Sea.

What is the approximate upper size limit of juvenile fish (in cm)?

The size of 50 percent maturity is 9.4 cm carapace length for females from Olga Bay, and 8.7 cm for Prince William Sound. Male size at maturity has been found to be 8.7 and 9.3 cm carapace length at Olga Bay and Prince William Sound, respectively.

Provide source (agency, name and phone number, or literature reference) for any possible additional distribution data (do not include AFSC groundfish surveys or fishery observer data)

ADF&G, Petersburg, AK Tim Koeneman, (907) 772-3801
ADF&G, Homer, Charles Trowbridge, (907) 235-8191
ADF&G, Kodiak, Daniel Urban, (907) 486-1840

Habitat and Biological Associations (if known) Narrative

Egg/Spawning See Adults.

Larvae Blue king crab spend 3.5 to 4 months in pelagic larval stages before settling to the benthic life stage. Larvae are found in waters of depths between 40 to 60 m.

Juveniles Juvenile blue king crab require refuge substrate characterized by gravel and cobble overlaid with shell hash, and sponge, hydroid and barnacle assemblages. These habitat areas have been found at 40-60 m around the Pribilofs Islands. The habitat requirements of juvenile blue king crab have not been studied in the Gulf of Alaska.

Adults Adults occur most often between 45-75 m depth on mud-sand substrate adjacent to gravel rocky bottom. Female and juvenile crab are found in a habitat with a high percentage of shell hash. It has been suggested that spawning and successful recruitment of first in-star juveniles may depend on availability of nearshore rocky-cobble substrate for protection of both females and small juveniles. Spawning occurs in mid-spring. Larger older females reproduce biennially while small females tend to reproduce annually. Fecundity of females range from 50,000-200,000 eggs per female. Larger older crabs disperse farther offshore and are thought to migrate inshore for molting and mating.

SPECIES: Blue king crab, *Paralithodes platypus*

Stage - EFH Level	Duration or Age	Diet/Prey	Season/Time	Location	Water Column	Bottom Type	Oceano-graphic Features	Other
Eggs 1	14 mo.	NA	Starting April-May	BAYS	NA	NA	F	
Larvae 1	3.5 to 4 mo.		April-July	BAYS	P	NA	F	
Juveniles 1			All year	BAYS	D	CB, G, R	F	
Adults 1			Spawning Feb-Jun	BAYS	D	S, M, CB, G, R	F	

Habitat Description for GOA Golden king crab

Lithodes aequispina

Management Plan and Area(s)

No federal fishery management plan exists for the commercial king, Tanner and Dungeness crab fisheries in the Gulf of Alaska.

Life History and General Distribution

Golden king crab (*Lithodes aequispina*), also called brown king crab, range from Japan to the Sea of Okhotsk and the Bering Sea to British Columbia. In the north Pacific, golden king crab are found at depths from 120 m to 900 m. Golden king crab are usually found in high relief habitat such as inter-island passes and fiords, and often inhabit slopes. Size at sexual maturity depends on latitude ranging from 9.8 - 11 cm carapace length, with crabs in the northern areas maturing at smaller sizes. The fecundity of females in northern British Columbia ranges from 10,620 to 27,040 eggs for females ranging in size from 11 to 15 cm. The season of reproduction appears to be protracted, and may be year-round.

Fishery

The golden king crab fisheries are prosecuted using mesh covered pots. Some landings have occurred from the Kodiak and Prince William Sound areas but the primary fishery has occurred in Southeast Alaska. Since the mid-1960's there has been approximately 10 million pounds harvested. The peak catch of 1.0 million pounds occurred in the 1986/87 season. The fishing season runs from February 15 until closed by emergency order.

Relevant Trophic Information

Trophic information on the golden king crab in the Gulf of Alaska is lacking. In the Bering Sea the crab eats a variety of invertebrates including sponges, hydroids, polychaetes, mollusks, amphipods, decapod crustacea, ophiuroids, echinoids and fish.

Describe any potential gear impacts on the habitats of this or other species

What is the approximate upper size limit of juvenile fish (in cm)?

The size (carapace length) at 50% maturity for females in northern British Columbia is 10.6 cm; the size at maturity for males is 11.4 cm.

Provide source (agency, name and phone number, or literature reference) for any possible additional distribution data (do not include AFSC groundfish surveys or fishery observer data)

ADF&G, Petersburg, AK Tim Koeneman, (907) 772-3801
ADF&G, Homer, Charles Trowbridge, (907) 235-8191
ADF&G, Kodiak, Daniel Urban, (907) 486-1840

Habitat and Biological Associations (if known) Narrative

Golden king crab occur on hard bottom, over steep rocky slopes and on narrow ledges. Strong currents are prevalent. Golden king crab coexist with a diverse group of epifauna, including sponges, hydroids, coral, sea stars, bryozoans, and brittle stars.

Egg/Spawning Eggs brooded by females collected in southeastern Alaska and brought into the laboratory in March hatched from April to August. The total duration of hatching was 123 d.

Larvae Golden king crab larvae are lecithotrophic. The zoeal and glaucothoe stages last 2.2 months and probably occupy near-bottom waters before settling to the benthic life stage.

Juveniles Juvenile golden king crab are found throughout the depth range of the species. In British Columbia, juvenile crab are most common at depths >100 m.

Adults Adult crabs occur at all depths within their distribution. In northern British Columbia, males are less migratory and tend to inhabit shallower waters than females. Males are found from 50 to 150 m. Females usually mate and extrude eggs at <150 m, and brood eggs from 150 to 250 m. Post-spawned females are found from 200 to 400 m.

SPECIES: Golden king crab, *Lithodes aequispina*

Stage - EFH Level	**Duration or Age**	**Diet/Prey**	**Season/Time**	**Location**	**Water Column**	**Bottom Type**	**Oceano-graphic Features**	**Other**
Eggs 0				IP, BAY, OCS, USP		R		
Larvae 0	2.2 mo	Yolk			SP			
Juveniles 0						R		
Adults 0		Ophiuroids, sponges, plants, polychaetes, amphipods, echinoids, hydroids	Spawning Feb.-Aug.			R		

Habitat Description for GOA Scarlet king crab
Lithodes couesi

Management Plan and Area(s)
No federal fishery management plan exists for the commercial king, Tanner and Dungeness crab fisheries in the Gulf of Alaska.

Life History and General Distribution
The scarlet king crab (*Lithodes couesi*) is distributed from Onohama, Japan to the Bering Sea to San Diego, California. It is a deep water species found primarily on the continental slope and on seamounts in the depth range 258 to 1829 m. Little information is available on the biology of the scarlet king crab. Spawning may be asynchronous. Fecundity increases up to a size of 9.5 cm carapace length (CL), then remains relatively constant as size increases further. Fecundity ranges from 2,700 to 5,500 eggs in females ranging in size from 8.3 to 11.5 cm CL. Crabs have been observed brooding eggs in June and July in the Gulf of Alaska; crabs have not been sampled in other months.

Fishery
Directed fishing for scarlet king crab may only occur under conditions of a permit issued by the Commissioner of Fish and Game. Fishing operations are restricted to pot gear only in waters 200 fathoms or greater in depth. Exploratory fishing has been minor with only a few small landings recorded from the Gulf of Alaska.

Relevant Trophic Information
Unknown.

What is the approximate upper size limit of juvenile fish (in cm)?
The estimated size (carapace length) of 50% maturity for female and males is 8 cm and 9.1 cm in the Gulf of Alaska.

Provide source (agency, name and phone number, or literature reference) for any possible additional distribution data (do not include AFSC groundfish surveys or fishery observer data)

ADF&G, Petersburg, AK Tim Koeneman, (907) 772-3801
ADF&G, Homer, Charles Trowbridge, (907) 235-8191
ADF&G, Kodiak, Daniel Urban, (907) 486-1840

Habitat and Biological Associations (if known) Narrative
On seamounts adult and subadult scarlet king crab are associated with steep rocky outcrops and narrow ledges interspersed with sediments. The species is also found on the continental slope of southeastern Alaska. Strong currents are often prevalent in these habitats.

Egg/Spawning Eggs are large, averaging 2.3 mm in length.

Larvae Stage 1 zoeae of *L. couesi* have substantially more yolk than red king crab (Paralithodes camtschaticus) suggesting that they may be lecithotrophic. The distribution of *L. couesi* larvae in the water column is not known.

Juveniles Subadults have been collected in the same habitats as adults on seamounts (see below).

Adults In the Gulf of Alaska, adults have been found on seamounts in the depth range 384 to 850 m. The species occurs deeper (> 592 m) on the continental slope in southeastern Alaska.

SPECIES: Scarlet king crab, *Lithodes couesi*

Stage - EFH Level	Duration or Age	Diet/Prey	Season/Time	Location	Water Column	Bottom Type	Oceano-graphic Features	Other
Eggs 0				USP, LSP		R		
Larvae 0								
Juveniles 0				USP		R		
Adults 0				USP, LSP		R		

Habitat Description for GOA Tanner crab
Chionoecetes bairdi

Management Plan and Area(s)
No federal fishery management plan exists for the commercial king, Tanner and Dungeness crab fisheries in the Gulf of Alaska.

Life History and General Distribution
Tanner crabs (*Chionoecetes bairdi*) are distributed on the continental shelf of the North Pacific Ocean and Bering Sea from Kamchatka to Oregon. In Alaska, Tanner crabs are concentrated around the Pribilof Islands and immediately north of the Alaska Peninsula, and are found in lower abundance in the Gulf of Alaska and throughout the Alexander Archipelago. Crabs occur from the littoral zone to 473 m. Females reach a terminal size with their maturity molt. Large numbers of small-clawed males migrate into shallow waters (<18 m) of Southeast Alaska bays and inlets to molt en masse in March and April. Mature male Tanner crabs may skip a year or more of molting after they attain maturity. Adult male crabs have limited migratory movements. Female crabs also have limited annual migrations especially while brooding eggs. Eggs generally hatch from March through May in the Gulf of Alaska, and peak hatching occurs in early May in Southeast Alaska (Robert Stone, NMFS, Auke Bay Laboratory, personal observation).

Fishery
The Tanner crab fisheries have been prosecuted in the Gulf of Alaska since 1967. Approximately 700 million pounds have been harvested since that time. The gear has evolved to include side loading mesh covered pots approximately 6 to 8 feet square and top loading pyramid or conical style gear. Fisheries have occurred in the South Peninsula, Chignik, Kodiak, Cook Inlet, Prince William Sound, Yakutat and Southeast Alaska Management Areas. The peak harvest of 54 million pounds was taken in 1978 with the Kodiak area contributing 33 million pounds. Tanner crab populations and fisheries diminished after that time with no harvest from the South peninsula and Chignik areas after 1989. Prince William Sound has remained closed since 1988. Kodiak and Cook Inlet had their most recent fisheries in 1994. Small fisheries continue to occur in Yakutat Bay and Southeast Alaska. The fishing season runs from February 15 through May 1.

Relevant Trophic Information
Tanner crab larvae are planktotrophic feeding on phytoplankton and small zooplankton. Crabs of different size, sex and state of maturity consume similar prey species, but diet differs from one area to another depending on prey availability. Food of juvenile crabs includes other crabs, bivalves, polychaetes, ophiuroids, barnacles, and sediment. Cannibalism may be prevalent in juvenile crabs. Adults near Kodiak are opportunistic and feed mainly on arthropods (mainly juvenile *C. bairdi*), fish, mollusks and polychaetes. In Southeast Alaska, polychaetes constitute a large portion of the diet of adult crabs.

Throughout their range *Chionoecetes* spp. are prey for at least seven species of invertebrates, twenty-six species of fishes, and four species of marine mammals. Pacific cod (*Gadus macrocephalus*) is the main predator on Tanner crabs in the Kodiak Island area; crabs up to 70 mm CW are consumed but most are between 7 and 23 mm CW. Sculpins (*Myoxocephalus* spp.) are also an important predator of crabs in the Kodiak area, including ovigerous females. Both adult and juvenile *C. bairdi* are cannibalistic. Other demersal fishes, including the yellow Irish Lord (*Hemilepidotus jordani*), are important predators. Larval predators include salmon, herring, jellyfish and chaetognaths. In the Gulf of Alaska juvenile coho salmon (*Oncorhynchus kisutch*) are important predators of Tanner crab zoeae[3]

Describe any potential gear impacts on the habitats of this or other species

Bottom trawls and dredges could disrupt nursery and adult molting and mating areas.

What is the approximate upper size limit of juvenile crab (in mm)?

One hundred percent of male *C. bairdi* 80 mm CW from the GOA are sexually mature as determined from the presence of spermatophores in the vas deferens and mating experiments. Estimates of the median size at maturity (SM_{50}) or mean size at maturity for Kodiak Island males are between 100 and 115 mm CW. The size of 50% maturity for females (50% have undergone the molt to maturity) was estimated at 83 mm CW. Since females do not continue to grow after maturity, measuring the mean size of a sample of multiparous females would reflect the mean size at maturity. Using this method, the mean size at maturity would be 97.3 mm CW for Kodiak Island females and 103.7 mm CW for Southeast Alaskan females.

Provide source (agency, name and phone number, or literature reference) for any possible additional distribution data (do not include AFSC groundfish surveys or fishery observer data)

ADF&G, Petersburg, AK Tim Koeneman, (907) 772-3801

---

[3] Pers. comm., Mary Auburn-Cook, NMFS, Alaska Fisheries Science Center, Auke Bay Laboratory, Juneau AK.

ADF&G, Homer, Charles Trowbridge, (907) 235-8191
ADF&G, Kodiak, Daniel Urban, (907) 486-1840

<u>Habitat and Biological Associations (if known) Narrative</u>

In May and June, Age 1 crabs are abundant in Cook Inlet at 150 m depth in areas where small sponges, hydroids, and polychaete tubes dominated the benthic community. Ovigerous female crabs often bury in the sediment while brooding eggs.

<u>Egg/Spawning</u> See Adults

<u>Larvae</u> There are two zoeal stages which inhabit the upper and middle zones of relatively shallow water in Cook Inlet. Larvae are strong swimmers and perform diel vertical migrations in the water column (down at night). They usually stay near the depth of the chlorophyll maximum during the day. The length of time larvae take to develop is unknown, although it has been estimated at only 12 to 14 days. The first benthic stage (megalops) settles on the bottom.

<u>Juveniles</u> In Southeast Alaskan bays young-of-year crab (8 to 15 mm CW) are locally abundant in early fall on silt/fine sand slopes between 4 and 10 m depth (Robert Stone, National Marine Fisheries Service, Auke Bay Laboratory, personal observation). Age 2 crab (34 to 48 mm CW) are locally abundant in similar habitat between 10 and 20 m depth during spring. Numerous crabs < 40 mm were observed from a submersible on silt substrate at 225 m depth along the Southeast Alaska coast. These observations indicate that juveniles are either widely distributed or make extensive seasonal migrations with respect to depth.

<u>Adults</u> *C. bairdi* females have a terminal molt at maturity and breed for the first time in the soft-shelled state. In subsequent years multiparous crabs breed in the hard-shelled state and may use stored sperm to fertilize their eggs. Pubescent females molt and mate between January and May in nearshore waters (3-13 m) near Kodiak and between late-December and mid-June in the nearshore waters (4-19 m) of Southeast Alaska. Near Kodiak Island multiparous females are known to form high density mating aggregations consisting of hundreds of crabs per mound. These mounds may provide protection from predators and also attract males for mating. In Southeast Alaska, however, multiparous females have been observed mating in low-density aggregations in shallow water (including the intertidal zone) during May. Females have clutches of 50,000 to 400,000 eggs. Multiparous females annually produce an average of 170,000 eggs. Multiparous females carry and brood the embryos for one year after fertilization. Primiparous females may carry the fertilized eggs for as long as 1.5 years.

SPECIES: Tanner crab, *Chionoecetes bairdi*

Stage - EFH Level	**Duration or Age**	**Diet/Prey**	**Season/Time**	**Location**	**Water Column**	**Bottom Type**	**Oceano-graphic Features**	**Other**
Eggs 1	1 to 1.5 years	NA	All Year	ICS, MCS, OCS	D	Silt/Fine Sand		Carried by ovigerous female
Larvae 0	Unknown (12-14 d)	Diatoms Algae Zooplankton	April-September	MCS, ICS	P	NA	F	
Juveniles 1	1 to 5 years	Crustaceans polychaetes bivalves ophiuroids algae hydroids	All year	MCS, ICS, BAY,	D	Silt/Fine Sand		
Adults 1	5+ years	Polychaetes crustaceans mollusks hydroids	Spawning Late-December to June (peak April-May)	MCS, ICS	D	Silt/Fine Sand		

Habitat Description for GOA Grooved Tanner crab
Chionoecetes tanneri

Management Plan and Area(s)
No federal fishery management plan exists for the commercial king, Tanner and Dungeness crab fisheries in the Gulf of Alaska.

Life History and General Distribution
In the North Pacific Ocean the grooved Tanner crab (*Chionoecetes tanneri*) ranges from northern Mexico to Kamchatka. Little information is available on the biology of the grooved Tanner crab; existing information is from surveys conducted off the Oregon and British Colombian coasts and the Eastern Bering Sea. This species occurs in deep water (to 1925 m)of the outer continental shelf and continental slope and is uncommon at depths < 300 m. Male and female crabs are found at similar depths, especially during winter when mating probably occurs.

Fishery
Directed fishing for grooved Tanner crab may only occur under condition of a permit issued by the Commissioner of Fish and Game. The Gulf of Alaska was initially explored for deepwater Tanner crab in 1994. Six vessels participated in 1995 and landed 947,000 pounds. Most of the fishing occurred on the bank of continental shelf from 375-475 fathoms. Interest and landings declined in 1996 as the value of Tanner crab declined. There have been no landings since that time.

Relevant Trophic Information
Juvenile crabs (3-10 mm CW) are preyed upon by sablefish (*Anoplopoma fimbria*) and Dover sole (*Microstomus pacificus*).

What is the approximate upper size limit of juvenile fish (in mm)?
The SM_{50} (size at 50% maturity) is estimated at 119 mm CW for males and 79 cm CW for females in the eastern Bering Sea.

Provide source (agency, name and phone number, or literature reference) for any possible additional distribution data (do not include AFSC groundfish surveys or fishery observer data)

ADF&G, Petersburg, AK Tim Koeneman, (907) 772-3801
ADF&G, Homer, Charles Trowbridge, (907) 235-8191
ADF&G, Kodiak, Daniel Urban, (907) 486-1840

Habitat and Biological Associations (if known) Narrative

Egg/Spawning See Adults

Larvae Like other *Chionoecetes* spp., *C. tanneri* has a brief prezoeal stage followed by two zoeal stages and a megalops. The total pelagic period of the larvae is estimated at about 80 days. Larvae are probably planktotrophic and must migrate vertically to feed in surface waters where prey concentrations are greater. Larvae probably hatch during winter off the Oregon coast.

Juveniles Juvenile *C. tanneri* occur in shallower water than mature male crabs in the eastern Bering Sea.

Adults In the Eastern Bering Sea adult males may be found somewhat more shallower than females but sexes do not show clear segregation by depth. All reproductively active females mate and extrude eggs at about the same time of year. Mean fecundity of *C. tanneri* is 86,500 eggs. Reproduction is probably seasonal and synchronous and mating probably occurs during winter but as late as July. Like other members of the genus *Chionoecetes*, females probably have a terminal molt. Shell condition data suggest that male grooved Tanner crab continue to molt after maturity.

SPECIES: Grooved Tanner crab, *Chionoecetes tanneri*

Stage - EFH Level	**Duration or Age**	**Diet/Prey**	**Season/Time**	**Location**	**Water Column**	**Bottom Type**	**Oceano-graphic Features**	**Other**
Eggs	1 year	NA	All Year	USP, LSP	NA	Silt		
Larvae	About 80 days	Plankto-trophic	Late-Winter to ?		P	NA		
Juveniles	Unknown	Unknown	All Year	OCS,USP, LSP	NA	Silt		
Adults	Unknown	Polychaetes, crustaceans, ophiuroids	All Year	USP, LSP	NA	Silt		

Habitat Description for GOA Triangle Tanner crab
Chionoecetes angulatus

Management Plan and Area(s)
No federal fishery management plan exists for the commercial king, Tanner and Dungeness crab fisheries in the Gulf of Alaska.

Life History and General Distribution
In the eastern North Pacific Ocean the triangle Tanner crab (*Chionoecetes angulatus*) ranges from Oregon to the Sea of Okhotsk. Little information is available on the biology of the grooved Tanner crab; existing information is mostly from one survey conducted in the Eastern Bering Sea. This species occurs on the continental slope in depths > 300 m and has been reported as deep as 2,974 m in the eastern Bering Sea . Mature male crabs inhabit shallower depths (mean 647 m) than mature females (mean 748 m) in the eastern Bering Sea possibly indicating seasonal segregation by depth.

Fishery
Directed fishing for triangle Tanner crab may only occur under the conditions of a permit issued by the Commissioner of Fish and Game. There have not been any landings recorded from the Gulf of Alaska.

Relevant Trophic Information
Unknown.

Describe any potential gear impacts on the habitats of this or other species

What is the approximate upper size limit of juvenile fish (in cm)?
In the eastern Bering Sea, male triangle Tanner crabs reach 50% maturity at 91 mm CW and females at 58 mm CW.

Provide source (agency, name and phone number, or literature reference) for any possible additional distribution data (do not include AFSC groundfish surveys or fishery observer data)

ADF&G, Petersburg, AK Tim Koeneman, (907) 772-3801
ADF&G, Homer, Charles Trowbridge, (907) 235-8191
ADF&G, Kodiak, Daniel Urban, (907) 486-1840

Habitat and Biological Associations (if known) Narrative

Unknown

Egg/Spawning See Adults

Larvae Larvae are probably planktotrophic and must migrate vertically to feed in surface waters where prey concentrations are greater.

Juveniles Juvenile males are found at similar depths (650 m) as mature males.

Adults The mean depth occupied by mature males (647 m) is significantly less than that of mature females (748 m) indicating some pattern of sexual segregation by depth. Adult male crabs probably molt in June or July. All reproductively active females mate and extrude eggs at about the same time of year. Fecundity of triangle Tanner crabs increases with size. Females of 70 mm CW are estimated to have approximately

40,000 - 50,000 eggs. Reproduction is probably seasonal and synchronous and mating probably occurs during winter but as late as July. Like other members of the genus *Chionoecetes*, females probably have a terminal molt. Shell condition data suggest that male triangle Tanner crab continue to molt after maturity.

SPECIES: Triangle Tanner crab, *Chionoecetes angulatus*

Stage - EFH Level	**Duration or Age**	**Diet/Prey**	**Season/Time**	**Location**	**Water Column**	**Bottom Type**	**Oceano-graphic Features**	**Other**
Eggs	Probably 1 year	Unknown	All year	USP, LSP	NA	Silt		
Larvae	Unknown	Unknown	Late-winter and spring ?	NA	P			
Juveniles	Unknown	Unknown	All year	USP, LSP	NA	Silt		
Adults	Unknown	Unknown	All year	USP, LSP	NA	Silt		

Habitat Description for Dungeness Crab
Cancer magister

Management Plan and Area(s)
No federal fishery management plan exists for the commercial king, Tanner and Dungeness crab fisheries in the Gulf of Alaska.

Life History and General Distribution
The Dungeness crab is distributed from the Pribilof Islands, Alaska, to Santa Barbara, California. A single specimen has been collected on Amchitka Island, Alaska; the published western limit of distribution is Tanaga Island, Aleutian Islands, Alaska. The species is found from the intertidal region to a depth of 230 meters. In northern Puget Sound, Washington, males and females reach sexual maturity at 10.0 cm in width in their second year of life. Females mate for the first time in their second year; males mate first in their third year. In southeastern Alaska, male/female pairs have been observed in premating embrace from May to December (Charles O'Clair, National Marine Fisheries Service, Auke Bay Laboratory, personal observation), but the peak period of mating is July to October has seen. In more southern waters crabs mate from April to September in British Columbia, and March to June in Washington. Males embrace smaller females about to molt for seven to eight days. Mating occurs about an hour after the female molts. During mating the male deposits spermatophores in the spermathecae (receptive organs) of the female. Mating lasts up to two hours or more. After mating in the laboratory, the male embraces the female again for two days. In nature, males have been observed standing over or near buried females with soft exoskeletons. Presumably the male is guarding the female until her new exoskeleton hardens. A female can retain viable sperm through a molt as well as retain sperm for at least 2.5 years and use it to fertilize an egg clutch that develops normally.

In Washington, both sexes migrate offshore away from estuaries after the mating season. Females might undertake these migrations to avoid exposure of their eggs to osmotic stress when the eggs are extruded. In Oregon, female crabs migrate inshore in order to reach the sandy bottoms they require for the proper formation of their egg clutches at the time of egg extrusion. In southeastern Alaska, the females mate and brood their eggs in shallow water (less than 10 m) on sandy bottoms in estuaries. Ovigerous crabs often aggregate in sandy areas near stream mouths, and are presumably exposed to low salinities in these areas.

Fertilization of the eggs takes place when the female extrudes the eggs onto the setae of her pleopods. Egg extrusion usually occurs several months after mating. In Southeastern Alaska, egg extrusion occurs in August-October; September-February in British Columbia, and October-December in Washington and Oregon. Fecundity ranges from 134,100 to 1,545,940 eggs/brood in females ranging in carapace width from 11.0 to 16.6 cm.

Hatching occurs in late April-June in southeastern Alaska. For those females in glacial systems, hatching takes place when glacial runoff is high and surface salinities are low. In the Queen Charlotte Islands hatching occurs in late April, throughout British Columbia in December-June, and in Washington in January-April. The larvae hatches as a prezoea and molts to the first zoeal stage within an hour. The five zoeal stages and the megalopal stage together last 90-110 d at 10°C; the megalopal stage alone lasts 25-30 d.

The period of peak settlement of Dungeness crab megalopae varies with latitude. Throughout British Columbia settlement occurs in July or later (in the Queen Charlotte Islands it peaks in late August-September); May to August in Washington. The first juvenile stage appears in greatest numbers in late May or early June at a carapace width of about 0.7-0.8 cm. The maximum age of the Dungeness crab is about eight years.

Fishery

Dungeness fishing in the Gulf of Alaska dates back to the 1930's. Prior to 1960, landings were combined into a single total. Since then, catch records detail harvest from the Alaska Peninsula, Kodiak, Cook Inlet, Prince William Sound, Yakutat and Southeast Alaska management areas. All registration areas in Alaska apply generally passive management measures limiting the size and sex of harvested animals. Gear has been limited to pots or ring nets with two escape rings of 4 3/8" diameter required in each pot. Since 1960, approximately 263 million pounds of Dungeness crab have been harvested from the Gulf of Alaska.

Relevant Trophic Information

Dungeness crabs are generalist predators that consume a variety of invertebrates and fish. A large part of the diet of adult Dungeness crabs in British Columbia is clams. In Hecate Strait near the Queen Charlotte Islands where 116 prey species have been identified in the stomachs of the crab, juvenile Pacific Razor Clams (*Siliqua patula*) and the Alaska Bay Shrimp (*Neocrangon* alaskensis)] are a major component of the diet of Dungeness crabs. The crab will prey on Pacific Oysters (*Crassostrea gigas*) planted on the bottom at oyster farms. In Southeastern Alaska, Dungeness crabs have been observed eating various species of bivalves including the Pacific Blue Mussel (*Mytilus trossulus*), the Nuttall Cockle (*Clinocardium nuttallii*), and *Macoma* sp. Crabs were also seen carrying the Butter Clam (*Saxidomus giganteus*) and the Kennerley Venus (*Humilaria kennerleyi*) in their claws, presumably with the intent of eating them (Charles O'Clair, National Marine Fisheries Service, Auke Bay Laboratory, personal observation). Dungeness crabs have been observed "digging-up" (to a depth of 0.3 m) and clutching large Nuttall Cockles (*Clinocardium nuttallii*) in Southeastern Alaska. The crabs will also scavenge animal flesh. They have been observed feeding on the carcasses of Pacific Halibut (*Hippoglossus stenolepis*) and unidentified flatfish in southeastern Alaska (Charles O'Clair, National Marine Fisheries Service, Auke Bay Laboratory, personal observation). At San Juan Island in northern Puget Sound, Washington, adult Dungeness crabs move into the intertidal zone during nocturnal high tides, and feed mostly on bivalves and polychaetes. Elsewhere on the coast of Washington, crustaceans and fish are important food items in the diet of adult crabs.

Dungeness crab larvae are primarily zooplankton predators, although phytoplankton are also eaten. In the laboratory, the larvae can be raised to the megalopal stage with reasonably good survival on the diatom, *Skeletonema* sp. and the brine shrimp, *Artemia* sp.. Juvenile crabs (less than 10.0 cm in carapace width) eat primarily crustaceans in the Queen Charlotte Islands, British Columbia, and fish in California. In Grays Harbor, Washington, juvenile crabs eat primarily small bivalves and small crustaceans in their first year, shrimp (*Crangon* spp.) and fish in their second year, and fish in their third year. Both juvenile and adult crabs are cannibalistic, but the frequency of cannibalism is greatest in crabs less 6.0 cm in width, which prey on smaller crabs of the same year class.

The various life stages of the Dungeness crab are consumed by a diverse group of predators. The nemertean, *Carcinonemertes errans*, eats crab eggs and can cause heavy mortality (over 55%) in Dungeness crab egg clutches. In Oregon and northern California, the megalopae are preyed upon by King Salmon (*Oncorhynchus tshawytscha*) and Coho Salmon (*O. kisutch*) as well as by other fishes, such as the Copper Rockfish (*Sebastes caurinus*). Sea birds also consume the megalopae. In California, the Giant Pink Star (*Pisaster brevispinus*) preys on newly-settled megalopae and small juvenile crabs.

In addition to falling prey to larger conspecifics, juvenile Dungeness crabs suffer predation from a wide variety of invertebrates, fish, birds and mammals. In Grays Harbor on the outer coast of Washington, the Staghorn Sculpin (*Leptocottus armatus*) is a major predator of newly-settled Dungeness crabs in late spring and early summer; in Puget Sound, large juvenile crabs are found in stomachs taken from this fish. Crabs up to 11.4 cm in carapace width are consumed by the Pacific Halibut (*Hippoglossus stenolepis*) in Alaska and by the Cabezon (*Scorpaenichthys marmoratus*) in Oregon. Wading birds also prey on young crabs.

Perhaps the most important predator on adult Dungeness crabs in certain areas of Alaska is the sea otter (*Enhydra lutris*). The dramatic decline in crab abundance in Orca Inlet, Prince William Sound, beginning in 1979 has been attributed to predation by sea otters which prey heavily on Dungeness crabs in Prince William Sound. Sea otter predation is also probably responsible for a recent decrease in the abundance of Dungeness crabs in part of Dundas Bay, Glacier Bay National Park, Alaska. Octopuses also prey on adult crabs. Intertidal juveniles and large crabs in poor health are subject to bird predation. Bald eagles (*Haliaeetus leucocephalus*), northwestern crows (*Corvus caurinus*), and gulls (*Larus* sp.) Have been observed eating the eggs of apparently previously healthy, ovigerous crabs that had been dug out of sand in which the crabs had buried themselves in the low intertidal zone (Robert Stone and Charles O'Clair, National Marine Fisheries Service, Auke Bay Laboratory, personal observation). One or more of these birds had excavated the females and inverted them to gain access to the crab's egg clutch. Virtually every female that had been attacked in this way was dead by the time they were observed. The Dungeness crab is also infrequently preyed upon by river otters (*Lutra canadensis*) in southeastern Alaska.

<u>What is the approximate upper size limit of juvenile fish (in cm)?</u>
Male and female Dungeness crabs reach sexual maturity at 10.0 cm in width.

<u>Provide source (agency, name and phone number, or literature reference) for any possible additional distribution data (do not include AFSC groundfish surveys or fishery observer data)</u>

ADF&G, Petersburg, AK Tim Koeneman, (907) 772-3801
ADF&G, Homer, Charles Trowbridge, (907) 235-8191
ADF&G, Kodiak, Daniel Urban, (907) 486-1840

<u>Habitat and Biological Associations (if known) Narrative</u>
Dungeness crabs are most common on sand or muddy-sand bottoms in the subtidal region, and are often found in or near eelgrass beds. However, in southeastern Alaska as well as elsewhere they can also be found on a variety of other substrata including various mixtures of silt, sand, pebble, cobble and shell.

<u>Egg/Spawning See Adults</u>

<u>Larvae</u> On the outer coasts of Washington, Oregon and California the zoeae are transported offshore. Subsequently, the megalopae are transported near shore, probably by wind-induced currents acting in conjunction with the diel vertical migratory behavior of the megalopae. Little is known of the movements and distribution of Dungeness crab larvae in southeastern Alaska. The megalopae have been observed among the gonozooids of the pelagic hydrozoan, *Velella velella*, collected 1-10 km from shore in northern California. The megalopae eat the gonozooids, gain protection from pelagic fish predators and possibly are transported to juvenile crab habitats nearshore while associated with the cnidarian. In northern Puget Sound, Washington, megalopae settle onto relatively open sandy areas where they are vulnerable to fish predation.

<u>Juveniles</u> Juvenile Dungeness crabs are found in similar habitats to the adults, but they generally occupy shallower depths than the adults. Juvenile crabs can be very abundant in the intertidal zone, but also occur in shallow subtidal areas. Survival of young crabs is greatest in habitats where they can gain refuge from predators such as in intertidal shell and eelgrass beds.

<u>Adults</u> In sand or muddy-sand the adult crabs frequently bury themselves so deeply that only their eyes, antennules and antennae are visible. Ovigerous crabs can bury themselves so completely that there is no visible indication of their presence on the surface of the sand. Crabs unencumbered by an egg clutch move very quickly, running on the tips of the walking legs. The crabs are especially fast over sand or mud bottoms where obstacles are lacking. In southeastern Alaska the amount of movement varies with the sex of the crab and the reproductive state of female crabs. On average, males move at a greater rate than females and ovigerous females move around less than males or nonovigerous females.

SPECIES: Dungeness crab, *Cancer magister*

Stage - EFH Level	**Duration or Age**	**Diet/Prey**	**Season/Time**	**Location**	**Water Column**	**Bottom Type**	**Oceano-graphic Features**	**Other**
Eggs	8-10 mo	NA	August - June	BAY, BCH, ICS	NA	S, MS		
Larvae	3-3.7 mo	Zooplankton, phytoplankton	June - September	BAY, ICS	P	NA		
Juveniles	0-2 yr	Crustaceans, bivalves, fish	All year	BAY, BCH,	NA	S, MS, G, CB, SAV		
Adults	2-8 yr	Bivalves, crustaceans, fish, polychaetes.	Spawning May - December	BAY, BCH, ICS	NA	S, MS, G, CB, SAV, M, SM		

GOA Crab Literature

Armstrong, D.A., J.L. Armstrong, R. Palacios, G. Williams, G.C. Jensen, and W. Pearson 1985. Early life history of juvenile blue king crab, *Paralithodes platypus*, around the Pribilof Islands. *In:* Proceedings of the International King Crab Symposium UA Sea Grant report No. 85-12:211-230.

Armstrong, J.L., D.A. Armstrong, and S.B. Mathews, 1994. Food habits of estuarine staghorn sculpin, *Leptocottus armatus*, with focus on consumption of juvenile Dungeness crab, *Cancer magister*. Fish. Bull. *93*:456-470.

Bernard, F.R., 1979. The food of Hecate Strait crabs. August 1977. MS Rep. Fish. Mar. Serv. Can. *1464*:1-23.

Blau, S.F., D. Pengilly, and D.A. Tracy. 1995. Distribution of Golden King crabs by sex, size and depth zones in the Eastern Aleutian Islands. *In*: International Symposium on Biology, Management, and Economics of Crabs from High Latitude Habitats. Lowell Wakefield Symposium, Univ. of Alaska Sea Grant College Program. AK-SG-96-02:167-186.

Bousfield, E.L. and D.E. McAllister, 1962. Station list of the National Museum Marine Biological Expedition to Southeastern Alaska and Prince William Sound. Bull. Nat. Mus., Canada *183*:76-103.

Bright, D.B., 1967. Life histories of the king crab, *Paralithodes camtschatica*, and the "Tanner" crab, *Chionoecetes bairdi*, in Cook Inlet, Alaska. Ph.D. Dissertation. University of Southern California, Los Angeles. 265 p.

Brodersen, C.C., P.M. Rounds, and M.M. Babcock, 1990. Diet influences cannibalism in laboratory-held juvenile red king crabs (*Paralithodes camtschatica*). p. 377-382. *In* B. Melteff (Symposium coordinator), Proceedings of the International Symposium on King and Tanner Crabs. Alaska Sea Grant Report 90-04. University of Alaska, Fairbanks. 633 p.

Brown, R.B., and G.C. Powell. 1972. Size at maturity in the male Alaskan Tanner crab *Chionoecetes bairdi*, as determined by chela allometry, reproductive tract weights, and size of precopulatory males. J. Fish. Res. Bd. Canada 29: 423-427.

Butler, T.H., 1954. Food of the commercial crab in the Queen Charlotte Islands region. Fish. Res. Board. Can. Prog. Rep. No.99: 3-5.

Butler, T.H., 1956. The distribution and abundance of early post-larval stages of the British Columbia commercial crab. Fish. Res. Board. Can. Prog. Rep. No.107:22-23.

Butler, T.H., 1967. A bibliography of the Dungeness crab, *Cancer magister* Dana. Fish. Res. Board. Can. Tech. Rep. No.1 12 p.

Carlson, H.R. and R.R. Straty. 1981. Habitat and nursery grounds of Pacific ocean perch, *Sebastes* spp., in rocky coastal areas of Southeastern Alaska. Marine Fisheries Review 43(7): 13-17.

Cleaver, F.C., 1949. Preliminary results of the coastal crab (*Cancer magister*) investigation. Wash. State Dept. Fish. Biol. Rep. No.49A:47-82.

DeBrosse, G., S. Sulkin, and G. Jamieson, 1990. Intraspecific morphological variability in megalopae of three sympatric species of the Genus *Cancer* (Brachyura: Cancridae). J. Crust. Biol. *10*:315-329.

Dew, C.B., 1990. Behavioral ecology of podding red king crab, *Paralithodes camtschatica*. Can. J. Fish. Aquat. Sci. *47*:1944-1958.

Donaldson, W.E. 1980. Movements of tagged male Tanner crabs, Chionoecetes bairdi, liberated off Kodiak Island, Alaska. Alaska Department of Fish and Game Informational Leaflet No. 188: 60p.

Donaldson, W.E., J. Hilsinger, and R.T. Cooney. 1980. Growth, age, and size at maturity of Tanner crab, *Chionoecetes bairdi* in the Gulf of Alaska. Alaska Department of Fish and Game Informational Leaflet No. 185: 52p.

Donaldson, W.E.,R.T. Cooney, and J.R. Hilsinger. 1981. Growth, age, and size at maturity of Tanner crab, *Chionoecetes bairdi* M.J. Rathbun. Journal of Crustacean Biology 9: 37-53.

Eldridge, P.J. 1972. Tanner crab fishery in the Gulf of Alaska. Pp. 267-286. *In*: A review of the oceanography and renewable resources of the northern Gulf of Alaska. Institute of Marine Science, University of Alaska. Report No. R72-23.

Engelhardt, F.R. and P.A. Dehnel, 1973. Ion regulation in the Pacific edible crab, *Cancer magister* (Dana). Can. J. Zool. *51*:735-743.

Feder, H.M., K. McCumby, and A.J. Paul, 1980. The food of post-larval king crab, *Paralithodes camtschatica*, in Kachemak Bay, Alaska (Decapoda, Lithodidae). Crustaceana *39*:315-318.

Feniuk, V.F., 1945. Analysis of stomach contents of king crab. Izvestiya Tikhookeansky, Nauchno-Issledovatelskogo Instituta Rybnogo Khozyaistvo i Okeanografii. *19*:71-78.(Translated from Russian by Leda Sagen for the Bureau of Commercial Fisheries, Seattle.)

Fernandez, M., O. Iribarne, and D. Armstrong, 1993. Habitat selection by young-of-the-year Dungeness crab *Cancer magister* and predation risk in intertidal habitats. Mar. Ecol. Prog. Ser. 92:171-177.

Freese, J.F. and C.E. O'Clair, 1987. Reduced survival and condition of the bivalves *Protothaca staminea* and *Mytilus edulis* buried by decomposing bark. Marine Environ. Res. *23*:49-64.

Garshelis, D.L., 1983. Ecology of sea otters in Prince William Sound, Alaska. Ph.D. Thesis, University of Minnesota, Minneapolis. 321 pp.

Garth, J.S., 1958. Brachyura of the Pacific coast of America. Oxyrhyncha. Allan Hancock Pacific Exped. *21*:1-854.

Gotshall, D.W., 1977. Stomach contents of northern California Dungeness crabs, *Cancer magister*. Calif. Fish. and Game *63*:43-51.

Gray, G.W., 1964. Halibut preying on large Crustacea. Copeia No. 3, p. 590.

Hart, J.F.L., 1968. Crab-like Anomura and Brachyura (Crustacea: Decapoda) from southeastern Alaska and Prince William Sound. Natural History Papers, National Museum of Canada, Ottawa, Ontario. *38*:1-6.

Hart, J.F.L., 1982. *Crabs and Their Relatives of British Columbia*. B.C. Provincial Museum, Handbook No. 40, Victoria, B.C. 267 pp.

Hankin, D.G., N. Diamond, M.S. Mohr, and J. Ianelli, 1989. Growth and reproductive dynamics of adult female Dungeness crabs (*Cancer magister*) in northern California. J. Cons. int. Explor. Mer *46*:94-108.

Hatfield, S.E., 1983. Distribution of zooplankton in association with Dungeness crab, *Cancer magister*, larvae in California. pp. 97-123. *In* P.W. Wild and R.N. Tasto, eds. Life History, environment, and mariculture studies of the Dungeness crab, Cancer

magister, with emphasis on the central California fishery resource. Calif. Dep. Fish and Game Fish Bull. 172. 352 p.
Hilsinger, J.R. 1976. Aspects of the reproductive biology of snow crabs, *Chionoecetes bairdi*, from Prince William sound and the adjacent Gulf of Alaska. Marine Science Communication 2: 201-225.
Hines, A.H., 1991. Fecundity and reproductive output in nine species of *Cancer* crabs (Crustacea, Brachyura, Cancridae). Can. J. Fish, Aquat. Sci. *48*:267-275.
Hobbs, R.C., L.W. Botsford, and A. Thomas. 1992. Influence of hydrographic conditions and wind forcing on the distribution and abundance of Dungeness crab, *Cancer magister*, larvae. Can. J. Fish. Aquat. Sci. 49:1379-1388.
Hughes, S.E. 1981. Initial U.S. exploration of nine Gulf of Alaska seamounts and their associated fish and shellfish resources. Mar. Fish. Rev. :26-33.
Jensen, G.C. and D.A. Armstrong, 1987. Range extensions of some northeastern Pacific Decapoda. Crustaceana *52*:215-217.
Jewett, S.C. 1982. Predation on crabs of the genus *Chionoecetes*: a literature review. Proceedings of the International Symposium on the Genus *Chionoecetes*, May 3-6, 1982. Lowell Wakefield Symposia Series, Alaska Sea Grant Program, University of Alaska. Pp. 521-538.
Jewett, S.C. and H.M. Feder, 1982. Food and feeding habits of the king crab *Paralithodes camtschatica* near Kodiak Island, Alaska. Mar. Biol. *66*:243-250.
Jewett, S.C. and H. M. Feder. 1983. Food of the Tanner crab *Chionoecetes bairdi* near Kodiak Island, Alaska. Journal of Crustacean Biology 3(2): 196-207.
Jewett, S.C. and C.P. Onuf, 1988. Habitat suitability index models: red king crab. U.S. Fish. Wild. Serv. Biol. Rep. 82(10.153), 34 p.
Jewett, S.C., N.A. Sloan and D.A. Somerton. 1985. Egg number and adult size in *Lithodes aequispina* from northern British Columbia. pp.137-143. *In* B. Melteff (Symposium coordinator), Proceedings of the International King Crab Symposium. Alaska Sea Grant Report 85-12. University of Alaska, Fairbanks. 507 p.
Jewett, S.C., N.A. Sloan and D.A. Somerton. 1985. Size at sexual maturity and fecundity of the fjord-dwelling golden king crab *Lithodes aequispina* Benedict from northern British Columbia. J. Crust. Biol. 5:377-385.
Kimker, A., 1985. Overview of the Prince William Sound management area Dungeness crab fishery. pp.77-84. *In* B. Melteff (Symposium coordinator), Proceedings of the Symposium on Dungeness Crab biology and management. Alaska Sea Grant Report 85-3. University of Alaska Fairbanks. 424 pp.
Korolev, N.G., 1964. The biology and industry of Kamchatka crab, *Paralithodes camtschatica* (Tilesius), in the southeastern Bering Sea. Trudy Vsesoyuznogo Nauchno-issledovatel'skogo Instituta Rybnogo Khozyaistvo i Okeanografii (VNIRO). Vol 49. and Izvestiya TINRO Vol. 51:99-105. (Translated from Russian by Translation Program, Bureau of Commercial Fisheries, Seattle.)
Kulichkova, V.A., 1955. The feeding habits of the Kamchatka crab in the spring-summer period on the coasts of Kamchatka and Sakhalin. Izvestiya Tikhookeansky, Nauchno-Issledovatelskogo Instituta Rybnogo Khozyaistvo i Okeanografii. (TINRO) Izvestiya 43:21-42. (Translated from Russian for the Ministry of Agriculture, Fisheries and Food, Fisheries Laboratory, Lowestoft, Suffolk, England)
Kurata, H., 1959. Studies on the larva and post-larva of *Paralithodes camtschatica* I. Rearing of the larvae, with special reference to the food of the zoea. Bull. Hokkaido Reg. Fish. Res. Lab. *20*:76-83. (Translated from Japanese by the Translation Bureau (RN), Foreign Languages Division, Department of the Secretary of State of Canada, Trans. Ser. No. 1181, 1968.)
Kuris, A.M., S.F. Blau, A.J. Paul, J.D. Shields and D.E. Wickhman. 1991. Infestation by brood symbionts and their impact on egg mortality of the red king crab, *Paralithodes camtschatica*, in Alaska: geographic and temporal variation. Can. J. Fish. Aquat. Sci. *48*:559-568.
Larsen, D.N., 1984. Feeding habits of river otters in coastal southeastern Alaska. J. Wildl. Manage. *48*:1446-1452.
Lawton, P. and R.W. Elner, 1985. Feeding in relation to morphometrics within the genus *Cancer*: evolutionary and ecological considerations. p.357-380. *In* B. Melteff (Symposium coordinator), Proceedings of the Symposium on Dungeness Crab biology and management. Alaska Sea Grant Report 85-3. University of Alaska Fairbanks. 424 pp.
Livingston, P.A., 1989. Interannual trends in Pacific cod, Gadus macrocephalus, predation on three commercially important crab species in the eastern Bering Sea. Fish. Bull. *87*:807-827.
Livingston, P.A., A. Ward, G.M. Lang, and M. Yang. 1993. Groundfish food habits and predation on commercially important prey species in the eastern Bering Sea from 1987 to 1989. NOAA Tech. Memo NMFS-AFSC-11.
Livingston, P.A. and Y. DeReynier 1996. Groundfish food habits and predation on commercially important prey species in the eastern Bering Sea from 1990 to 1992. AFSC Processed Report 96-04, NMFS, U.S. Dept. Commerce, 214 p.
Lough, R.G. 1974. Dynamics of crab larvae (Anomura, Brachyura) off the central Oregon coast, 1969-1971. Ph. D. Thesis, Oregon State University, Corvallis, 299 pp.
Lough, R.G., 1976. Larval dynamics of the Dungeness crab, *Cancer magister*, off the central Oregon coast, 1970-71. Fish. Bull. *74*:353-375.
MacGinitie, G.E., 1955. Distribution and ecology of the marine invertebrates of Point Barrow, Alaska. Smithsonian Misc. Collect. *128*:1-201.
MacKay, D.C.G. 1942. The Pacific edible crab, *Cancer magister*. Bull. Fish. Res. Bd. Can. 62:1-32.
Makarov, V.V., 1938. Crustacea: Anomura. Fauna of U.S.S.R. *10*(3):1-289. (Translated from Russian by Israel Program for Scientific Translations, Jerusalem, No. 225, 1962.)
Nakanishi, T., 1987. Rearing condition of eggs, larvae and post-larvae of king crab. Bull. Japan Sea Reg. Fish. Res. Lab. 37:57-161. (Translated by J. Kanda, Ocean Research Institute, U. Tokyo, Japan, 1987.)
O'Clair, C.E., 1977. Marine invertebrates in rocky intertidal communities. pp. 395-449. *In* M.L. Merritt and R.G. Fuller, eds. *The Environment of Amchitka Island, Alaska.* Technical Information Center, Springfield, Virginia, 682p.

O'Clair, C.E., R.P. Stone and J.L. Freese, 1990. Movements and habitat use of Dungeness crabs and the Glacier Bay fishery. pp. 74-77. *In* A.M. Milner and J.D. Wood, eds. Proceedings of the Second Glacier Bay Science Symposium: September 19-22, 1988. Gustavus, Alaska. U.S. Department of the Interior, National Park Service, Alaska Regional Office, Anchorage, Alaska. 165 p.

O'Clair, C.E., T.C.Shirley, and S.J. Taggart, 1996. Dispersion of adult *Cancer magister* at Glacier Bay, Alaska: variation with spatial scale, sex and reproductive status. pp. 209-227. *In* High Latitude Crabs: Biology, Management, and Economics. Alaska Sea Grant College Program Report No. 96-02, University of Alaska Fairbanks. 713 p.

Orensanz, J.M. and V.F. Gallucci, 1988. Comparative study of postlarval life-history schedules in four sympatric species of Cancer (Decapoda: Brachyura: Cancridae). J. Crust. Biol.*8*:187-220.

Orensanz, J.M., A.M. Parma, D.A. Armstrong, J. Armstrong and P. Wardrup, 1995. The breeding ecology of *Cancer gracilis* (Crustacea: Decapoda: Cancridae) and the mating systems of cancrid crabs. J. Zool., Lond. *235*:411-437.

Paul, A.J. 1984. Mating frequency and viability of stored sperm in the Tanner crab *Chionoecetes bairdi* (Decapoda:Majidae). Journal of Crustacean Biology 4(3); 375-381.

Paul, A.J. 1992. Second clutch viability of *Chionoecetes bairdi* Rathbun (Decapoda:Majidae) inseminated only at the maturity molt. Journal of Crustacean Biology 12(3): 438-441.

Paul, A.J., H.M. Feder, and S.C. Jewett. 1979. Food of the snow crab, *Chionoecetes bairdi* Rathbun, 1924, from Cook Inlet, Alaska (Decapoda:Majidae). Crustaceana Supplement 5:62-68.

Paul, A.J. and J.M. Paul, 1980. The effect of early starvation on later feeding success of king crab zoeae. J. Exp. Mar. Biol. Ecol. *44*:247-251.

Paul, A.J. and J.M. Paul. 1990. The size at the onset of maturity in male *Chionoecetes bairdi* (Decapoda, Majidae). *In*: Proceedings of the International Symposium on King and Tanner Crabs, Anchorage, Alaska, November 28-30, 1989. Pp. 95-103. University of Alaska, Alaska Sea Grant College Program Report No. 90-04.

Paul, A.J., J.M. Paul and K.O. Coyle, 1989. Energy sources for first-feeding zoeae of king crab *Paralithodes camtschatica* (Tilesius)(Decapoda, Lithodidae). J. Exp. Mar. Biol. Ecol. *130*:55-69.

Paul, J.M. 1982. Distribution of juvenile *Chionoecetes bairdi* in Cook Inlet. *In:* Proceedings of the International Symposium on the genus Chionoecetes. UA Sea Grant report No. 82-10: 173-189.

Pavlovskii, E.N., 1955. Atlas of the Invertebrates of the Far Eastern Seas of the USSR. Izdatel'stvo Akademii Nauk SSSR, Moskva, USSR. 457 pp.(Translated from Russian by Israel Program for Scientific Translations, Jerusalem, No. 1672, 1966.)

Pereyra, W.T. 1966. The bathymetric and seasonal distribution, and reproduction of adult Tanner crabs, *Chionoecetes tanneri* Rathbun, off the northern Oregon coast. Deep-Sea Res. 13:1185-1205.

Pereyra, W.T. 1972. Bathymetric and seasonal abundance and general ecology of the Tanner crab, *Chionoecetes tanneri* Rathbun (Brachyura:Majidae), off the northern Oregon coast. *In*: A.T. Pruter and D.L. Alverson (editors), Columbia River and adjacent ocean waters: Bioenvironmental studies, pp. 538-582. University of Washington Press, Seattle.

Powell, G.C. and R.B. Nickerson, 1965a. Aggregations among juvenile king crabs (*Paralithodes camtschatica,* Tilesius) Kodiak, Alaska. Anim. Behav. *13*:374-380.

Powell, G.C. and R.B. Nickerson 1965b. Reproduction of king crabs, *Paralithodes camtschatica* (Tilesius). J. Fish. Res. Bd. Canada *22*:101-111.

Rathbun, M.J., 1925. The spider crabs of America. Bull. U.S. Nat. Mus. *129*:1-613.

Rathbun, M.J., 1930. The cancroid crabs of America of the families Euryalidae, Portunidae, Atelecyclidae, Cancridae and Xanthidae. Bull. U.S. Nat. Mus. *152*:1-609.

Reilly, P.N. 1983. Predation on Dungeness crabs, *Cancer magister*, in central California. pp 155-169. *In* P.W. Wild and R.N. Tasto, eds. Life History, environment, and mariculture studies of the Dungeness crab, Cancer magister, with emphasis on the central California fishery resource. Calif. Dep. Fish and Game Fish Bull. 172. 352 p.

Rounds, P.M., C. Brodersen, and M.M. Babcock, 1990. Effects of cohort density and habitat on survival and growth of juvenile red king crab, *Paralithodes camtschatica*. pp.209-217. *In* B. Melteff (Symposium coordinator), Proceedings of the International Symposium on King and Tanner Crabs. Alaska Sea Grant Report 90-04. University of Alaska Fairbanks. 633 p.

Shirley, S.M. and T.C. Shirley, 1990. Diel feeding periodicity of larvae of the red king crab, Paralithodes camtschatica. pp.233-244. *In* B. Melteff (Symposium coordinator), Proceedings of the International Symposium on King and Tanner Crabs. Alaska Sea Grant Report 90-04. University of Alaska Fairbanks. 633 p.

Shirley, T.C. and L. McNutt. 1989. Precocious mating and trans-molt sperm retention by female Dungeness crabs. Am. Zool. *29*:131

Shirley, T.C., G. Bishop, C.E. O'Clair, S.J. Taggart, and J.L. Bodkin, 1996. Sea otter predation on Dungeness crabs in Glacier Bay, Alaska. pp.563-576. *In* High Latitude Crabs: Biology, Management, and Economics. Alaska Sea Grant College Program Report No. 96-02, University of Alaska Fairbanks. 713 p.

Shirley, T.C. and S.M. Shirley, 1989. Temperature and salinity tolerances and preferences of red king crab larvae. Mar. Behav. Physiol. *16*:19-30.

Shirley, T.C. and S. Zhou. 1997. Lecithotrophic development of the golden king crab *Lithodes aequispinus* (Anomura: Lithodidae). J. Crust. Biol. *17*:207-216.

Slizkin, A.G., and S.D. Bukin. 1989. Distribution, biology and abundance of blue crab, *Paralithodes platypus* in the Bering Sea. Pages 306-315 *In* Proceedings of the International Scientific Symposium on Bering Sea Fisheries. NOAA Tech. Memo NMFS F/NWC-163.

Sloan, N.A. 1985. Distribution by depth of *Lithodes aequispina* and *Paralithodes camtschatica* confined in northern British Columbia fjords. pp.63-68. *In* B. Melteff (Symposium coordinator), Proceedings of the International King Crab Symposium. Alaska Sea Grant Report 85-12. University of Alaska, Fairbanks. 507 p.

Snow, C.D. and J.R. Nielsen, 1966. Premating and mating behaviour of the Dungeness crab (*Cancer magister* Dana). J. Fish. Res.

Bd. Can. *23*:1319-1323.
Somerton, D.A. 1980. A computer technique for estimating the size of sexual maturity in crabs. Canadian Journal of Fisheries and Aquatic Sciences 37: 1488-1494.
Somerton, D.A. 1981. Contribution to the life history of the deep-sea king crab, *Lithodes couesi*, in the Gulf of Alaska. Fish. Bull 79(2):259-69.
Somerton, D.A., 1985. The disjunct distribution of blue king crab, *Paralithodes platypus*, in Alaska: some hypotheses. pp.13-23. *In* B. Melteff (Symposium coordinator), Proceedings of the International King Crab Symposium. Alaska Sea Grant Report 85-12. University of Alaska, Fairbanks. 507 p.
Somerton, D.A. and W. Donaldson. 1996. Contribution to the biology of the grooved and triangle Tanner crabs, *Chionoecetes tanneri* and *C. angulatus*, in the Eastern Bering Sea. Fishery Bulletin 94: 348-357.
Somerton, D.A. and R.A. MacIntosh. 1983. The size at sexual maturity of blue king crab, *Paralithodes platypus*, in Alaska. Fish. Bull. 81:621-628.
Stevens, B.G., D.A. Armstrong, and R. Cusimano, 1982. Feeding habits of the Dungeness crab *Cancer magister* as determined by the index of relative importance. Mar. Biol. *72*:135-145.
Stevens, B.G., W.E. Donaldson,, and J.E. Munk. 1993. Morphometry and maturity of paired Tanner crabs, *Chionoecetes bairdi*, from Shallow- and deepwater environments. Canadian Journal of Fisheries and Aquatic Sciences 50: 1504-1516.
Stevens, B.G., J.A. Haaga, and W.E. Donaldson. 1994. Aggregative mating of Tanner crabs, *Chionoecetes bairdi*. Canadian Journal of Fisheries and Aquatic Sciences 51: 1273-1280.
Stone, R.P. In preparation. Habitat fidelity and mass molting of Tanner crabs (*Chionoecetes bairdi*), in a Southeast Alaska Estuary.
Stone, R.P. and S.W. Johnson. 1997. Survival, growth, and bioaccumulation of heavy metals by juvenile Tanner crabs (*Chionoecetes bairdi*) held on weathered mine tailings. Bulletin of Environmental Contamination and Toxicology 58(5); 830-837.
Stone, R.P. and S.W. Johnson. In Press. Effect of prolonged exposure to mine tailings on survival and reproductive success of ovigerous Tanner crabs (*Chionoecetes bairdi*). Bulletin of Environmental Contamination and Toxicology.
Stone, R.P. and S.W. Johnson. In Preparation. Movements, seasonal distribution, and essential habitat of adult Tanner crabs (*Chionoecetes bairdi*) in a Southeast Alaska estuary.
Stone, R.P., C.E. O'Clair, and T.C Shirley, 1992. Seasonal migration and distribution of female red king crabs in a southeast Alaskan estuary. J. Crustacean Biol. *12*:546-560.
Stone, R.P., C.E. O'Clair, and T.C Shirley, 1993. Aggregating behavior of ovigerous female red king crab, *Paralithodes camtschaticus*, in Auke Bay, Alaska. Can. J. Fish, Aquat. Sci. *50*:750-758.
Strathmann, M.F. 1987. Phylum or Subphylum Crustacea, Class Malacostraca, Order Decapoda, Brachyura. pp. 451-475. *In* M.F. Strathmann, *Reproduction and Development of Marine Invertebrates of the Northern Pacific Coast.* Seattle, Wash., University of Washington Press, 670 pp.
Sundberg, K.A. and D. Clausen, 1977. Post-larval king crab (*Paralithodes camtschatica*) distribution and abundance in Kachemak Bay, Lower Cook Inlet, Alaska, 1976. pp. 747-766. *In* B.R. Melteff, ed. Alaska Fisheries: 200 years and 200 miles of change. Proceedings of the 29th Alaska Science Conference. ASG-79-6 Alaska Sea Grant Rep., Fairbanks, Alaska.
Tarverdieva, M.I. and K.A. Zgurovsky. 1985. On food composition of the deep-water crab species *Lithodes aequispina* Benedict and *Chionoecetes tanneri* Rathbun in the Bering and Okhotsk seas. pp. 319-329. *In* B. Melteff (Symposium coordinator), Proceedings of the International King Crab Symposium. Alaska Sea Grant Report 85-12. University of Alaska, Fairbanks.
Thomas, R.E. and S.D. Rice, 1992. Salinity tolerance of adult and juvenile red king crabs *Paralithodes camtschatica*. Comp. Biochem. Physiol. *103A*:433-437.
Trask, T. 1970. A description of laboratory-reared larvae of *Cancer productus* Randall (Decapoda, Brachyura) and a comparison to larvae of *Cancer magister* Dana. Crustaceana *18*:133-147.
Tsalkina, A.V., 1969. Characteristics of the epifauna of the west Kamchatka shelf (from "Problems of commercial hydrobiology"). Proc. All-Union Sci. Res. Inst. Mar. Fish. Oceanogr. (VNIRO) Trudy *65*:248-257. (Translated from Russian by the Translation Service, Fish. Res. Board Can. No. 1568, 1970.)
Vinogradov, L.G., 1947. The geographic distribution of the Kamchatka crab. Proc. All-Union Sci. Res. Inst. Mar. Fish. Oceanogr. (VNIRO) Trudy *22*:195-232.
Waldron, K.D., 1958. The fishery and biology of the Dungeness crab (Cancer magister Dana) in Oregon waters. Fish. Comm. Ore., Contrib. No. 24:1-43.
Wallace, M.M., C.J. Pertuit, and A.R. Hvatum, 1949. Contribution to the biology of the king crab (*Paralithodes camtschatica* Tilesius). U.S. Fish Wildl. Serv., Fish. Leafl. 340, 50p.
Weber, D.D. 1967. Growth of immature king crab *Paralithodes camtschatica* (Tilesius). Int. N. Pac. Fish. Comm., Bull. 21:21-53.
Wickham, D.E., 1979. The relationship between megalopae of the Dungeness crab, *Cancer magister*, and the hydroid, *Velella velella*, and its influence on abundance estimates of *C. magister* megalopae. Calif. Fish and Game 65:184-186.
Wickham, D.E., 1979. Predation by the nemertean *Carcinonemertes errans* on eggs of the Dungeness crab, *Cancer magister*. Mar. Biol. 55:45-53.
Wild, P.W., 1983. The influence of seawater temperature on spawning, egg development, and hatching success of the Dungeness crab, *Cancer magister*. pp. 197-213. *In* P.W. Wild and R.N. Tasto, eds. Life History, environment, and mariculture studies of the Dungeness crab, Cancer magister, with emphasis on the central California fishery resource. Calif. Dep. Fish and Game Fish Bull. 172. 352 p.
Wolotira, R.J., Jr., J.E. Munk, and J.H. Bowerman, Jr., 1984. Seasonal distribution and abundance of decapod larvae for the Kodiak Island region. Northwest and Alaska Fish. Cent. Process. Rep. 84-01. NMFS/NWAFC, Seattle, Washington. 167 p.

See table of contents for the following maps:

Red King Crab distribution Southeast Alaska

Red King Crab distribution GOA

Blue King Crab distribution Port Wells and Unakwik Inlet

Blue King Crab distribution Southeast Alaska

Golden King Crab distribution GOA

Golden King Crab distribution Southeast Alaska

Tanner Crab distribution GOA

Tanner Crab distribution Southeast Alaska

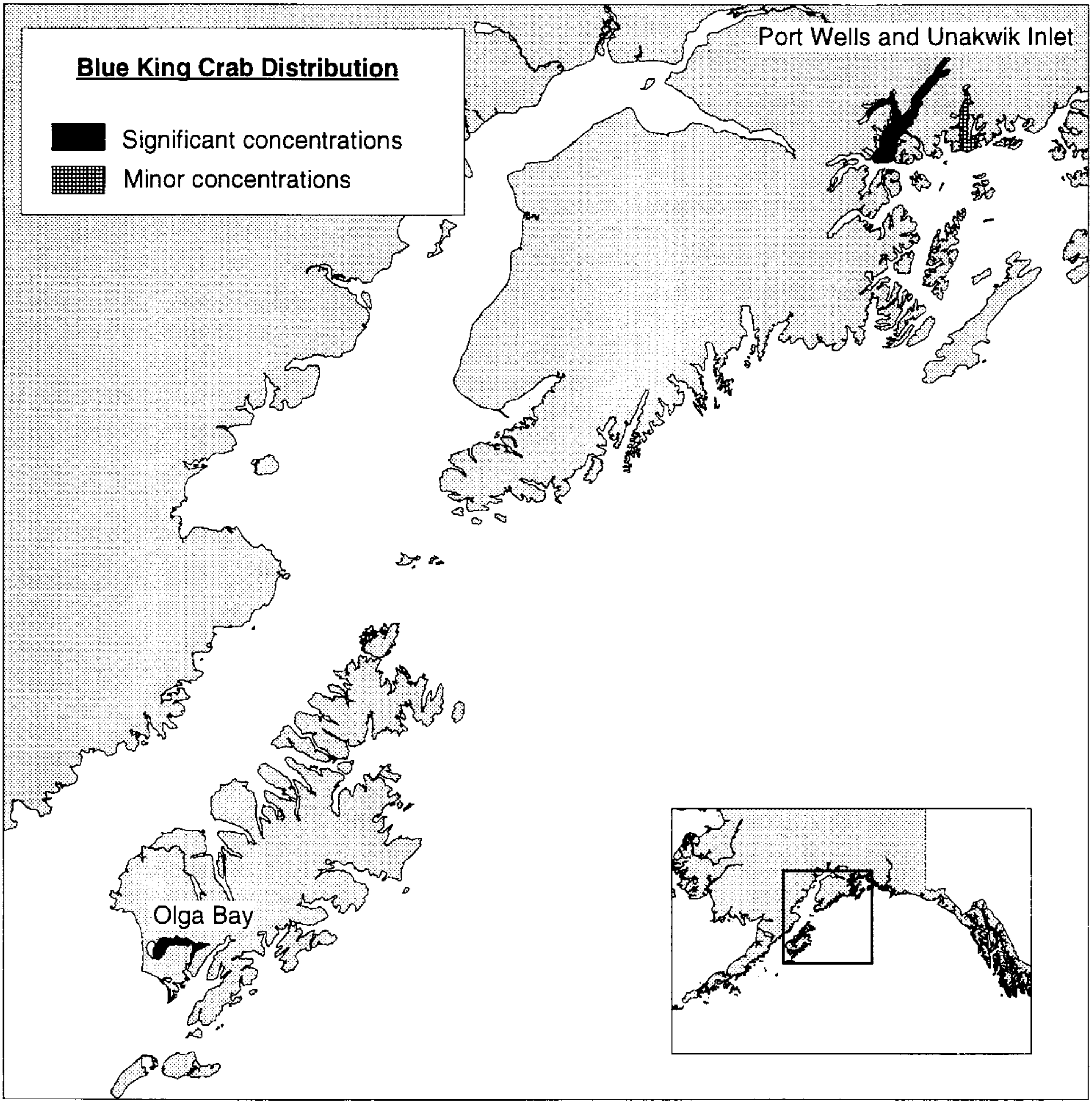
Deep Water Crab Distribution

Dungeness Crab Distribution Aleutian Islands

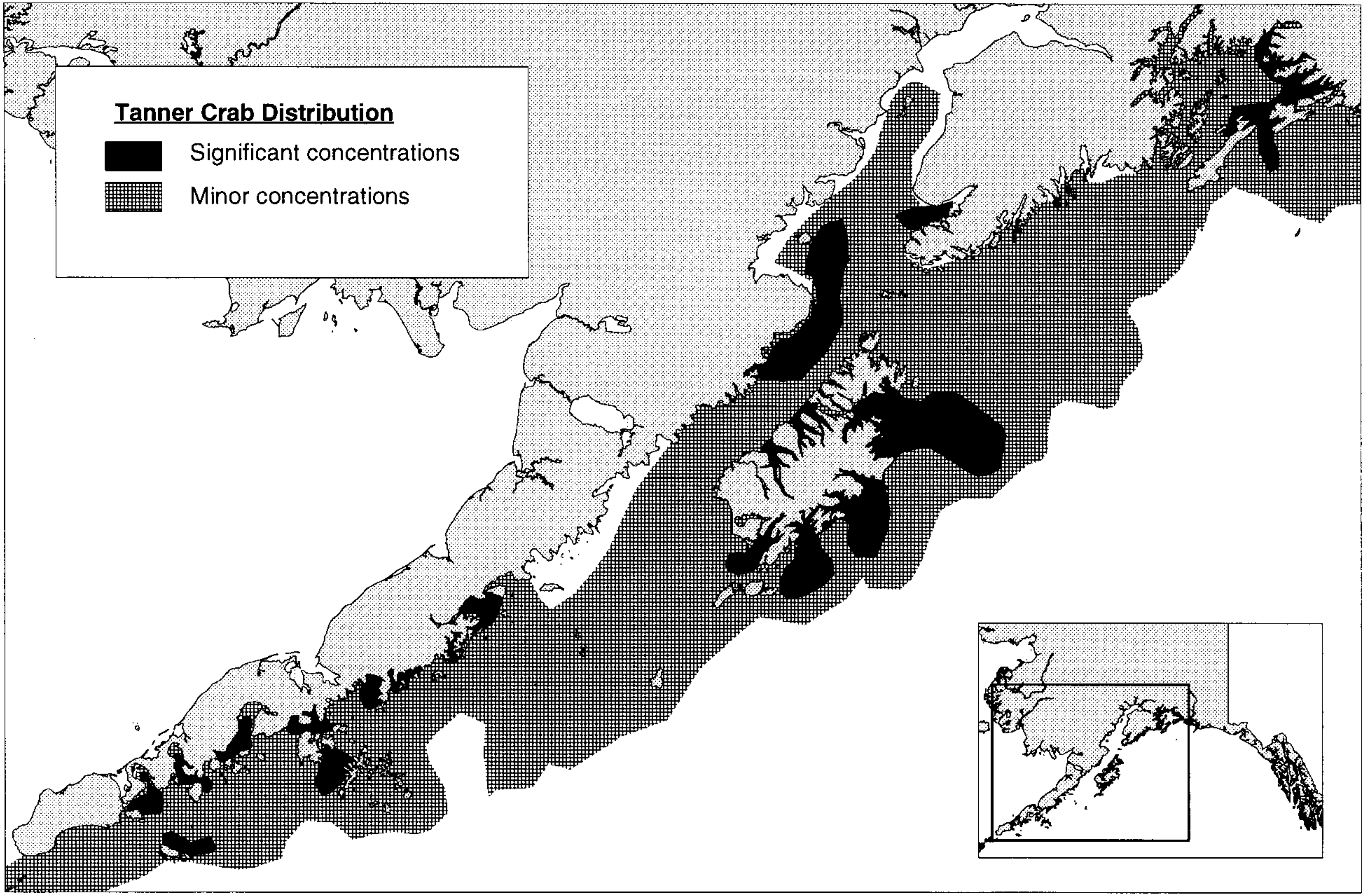
Dungeness Crab Distribution Kodiak

Dungeness Crab Distribution Northern Central Gulf

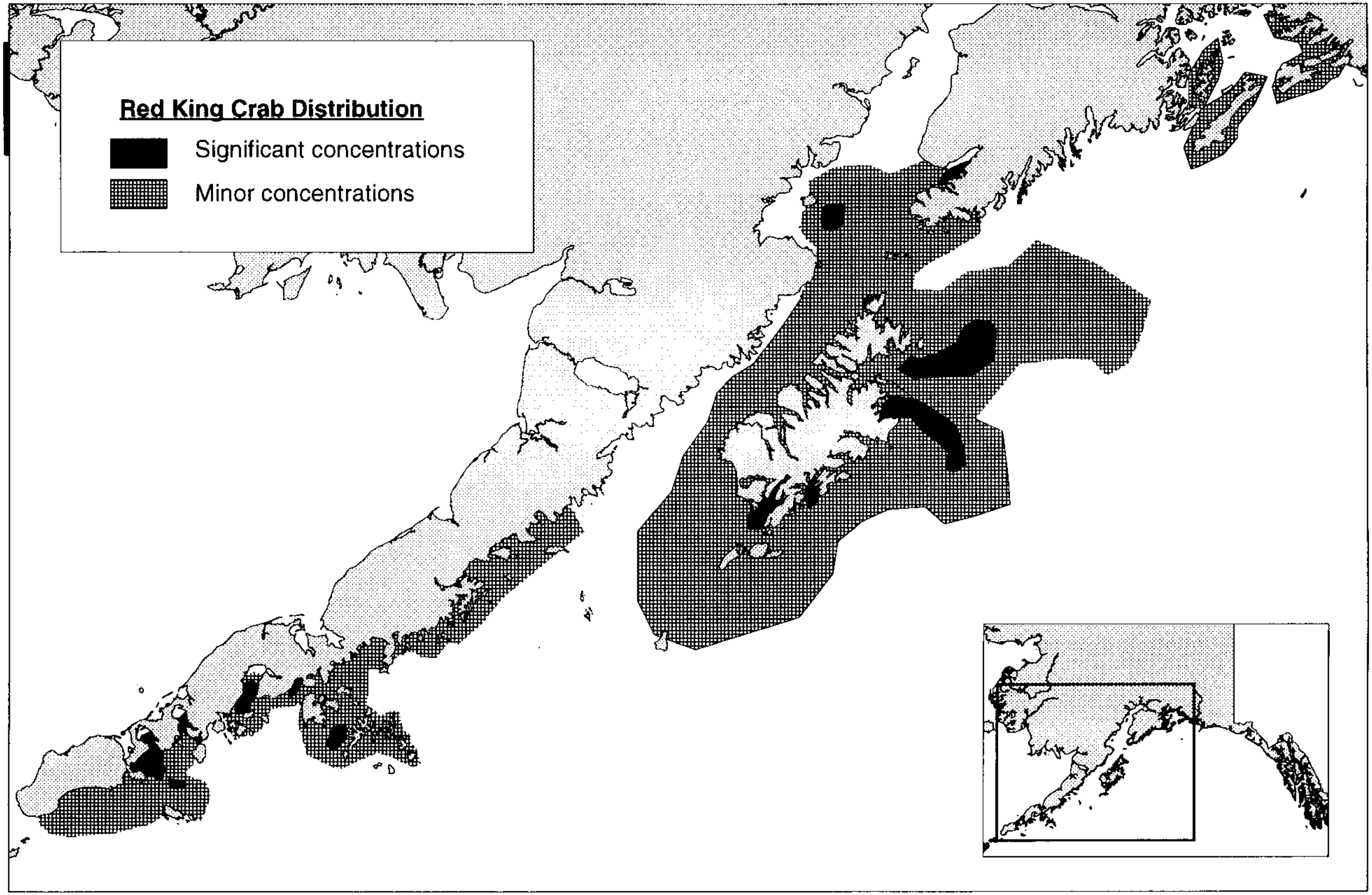
Dungeness Crab Distribution Southeast Alaska



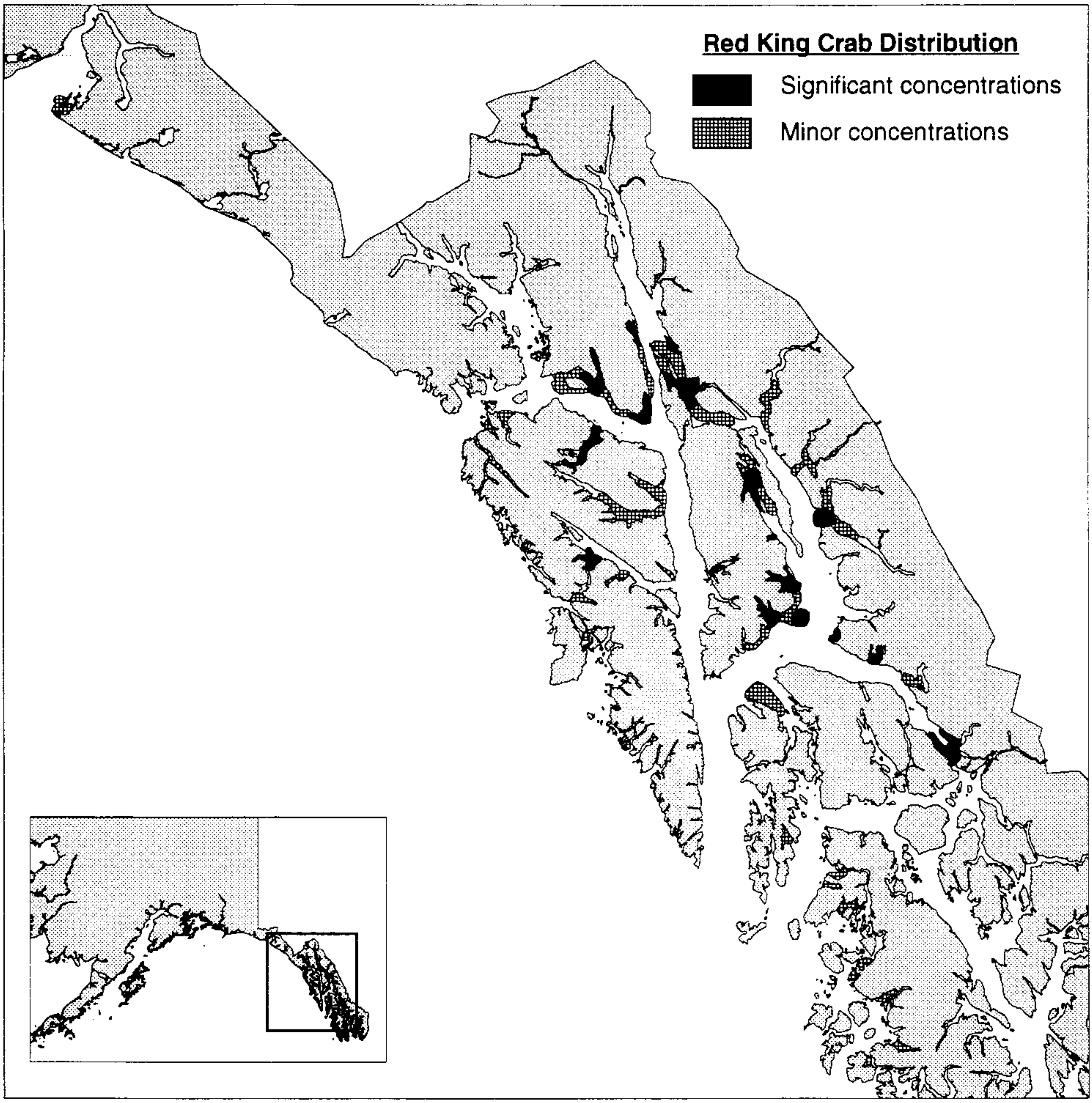
Source: ADF&G Fishticket database, Dave Jackson and Charles Trowbridge, pers. comm.



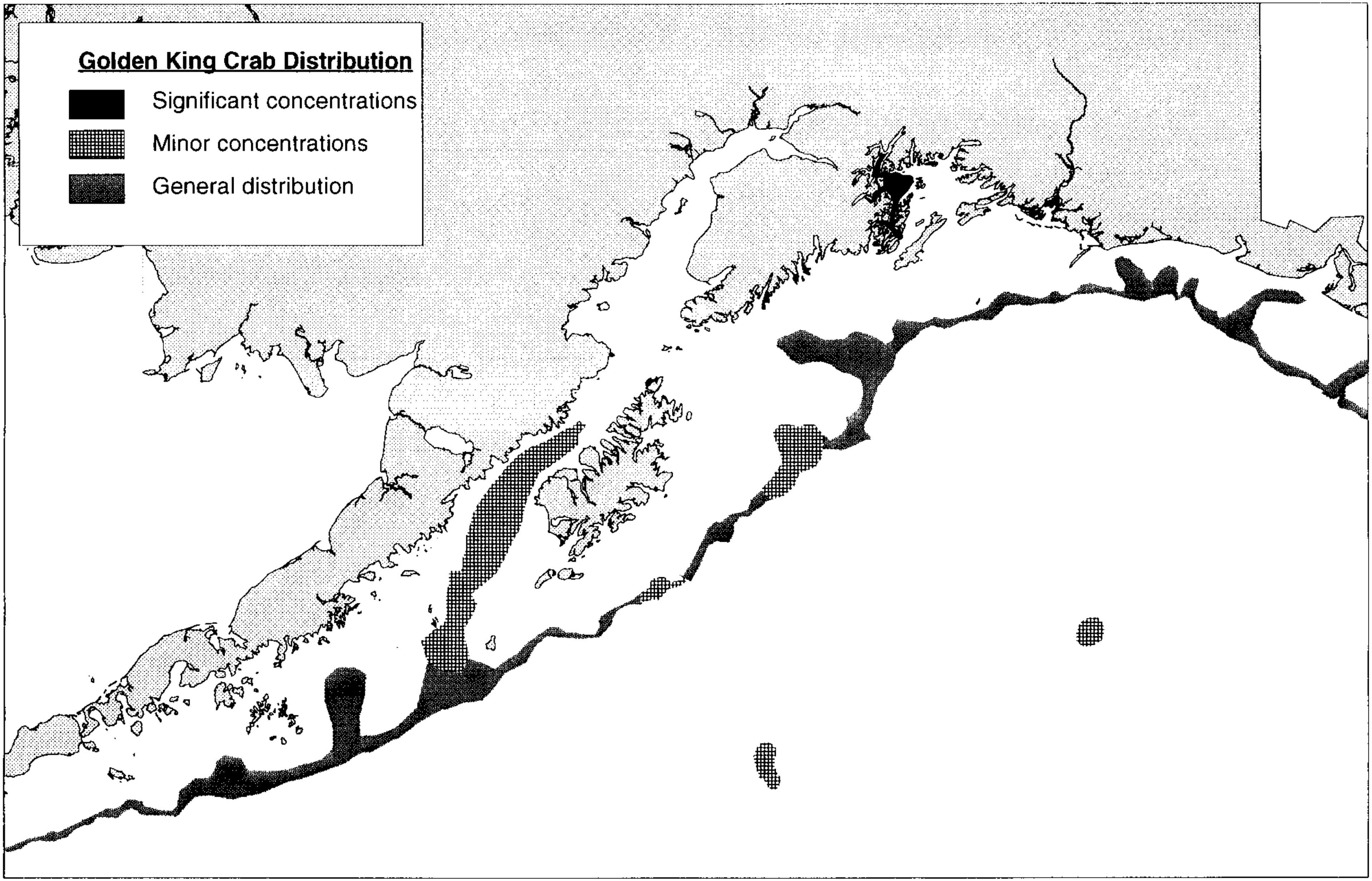
Source: ADF&G Survey Database, NMFS Survey Database, ADF&G Fish ticket database, U.S. Dept. of Commerce, 1990.



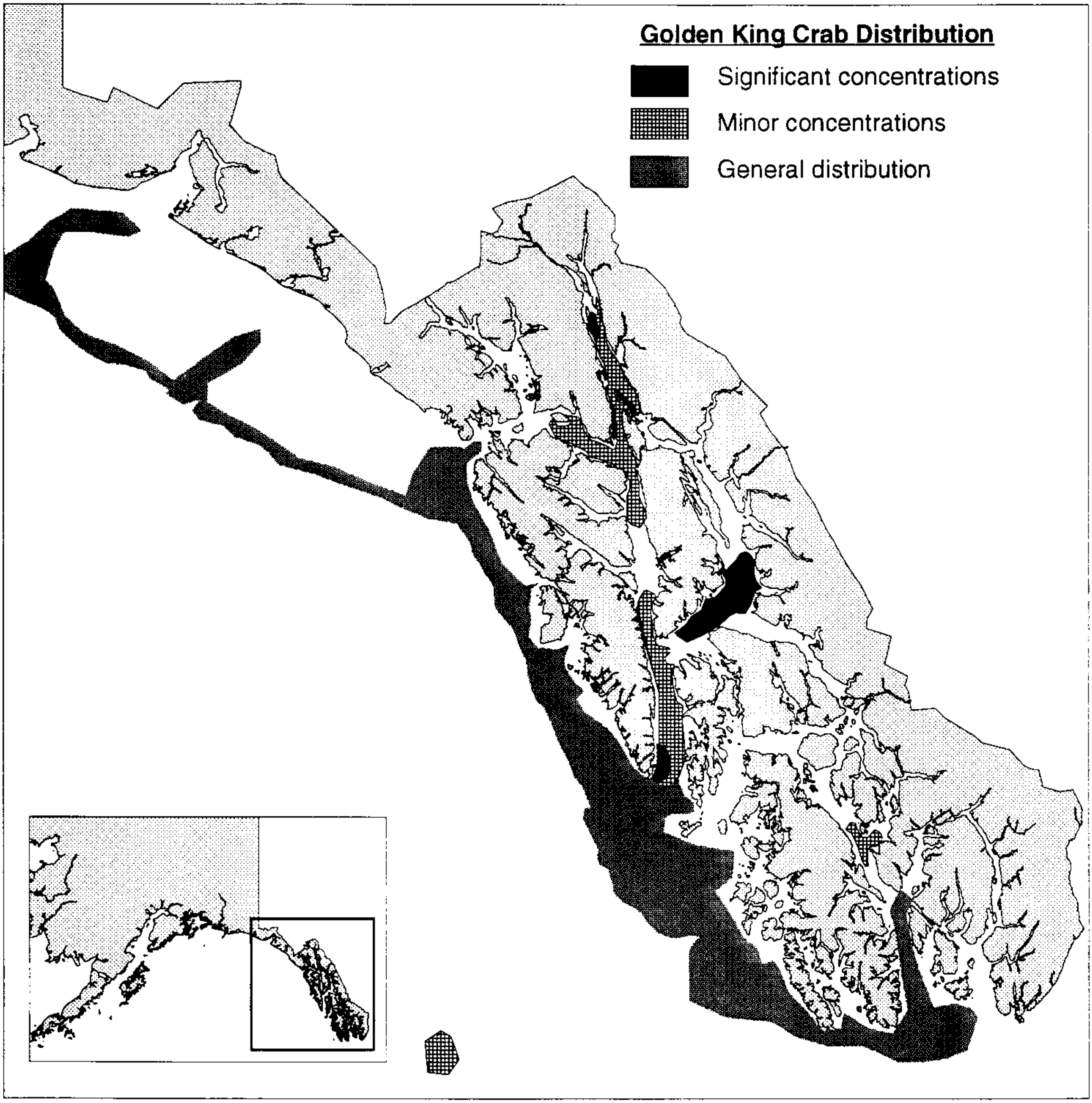
Source: ADF&G Survey Database, NMFS Survey Database, ADF&G Fish ticket database, U.S. Dept. of Commerce, 1990.



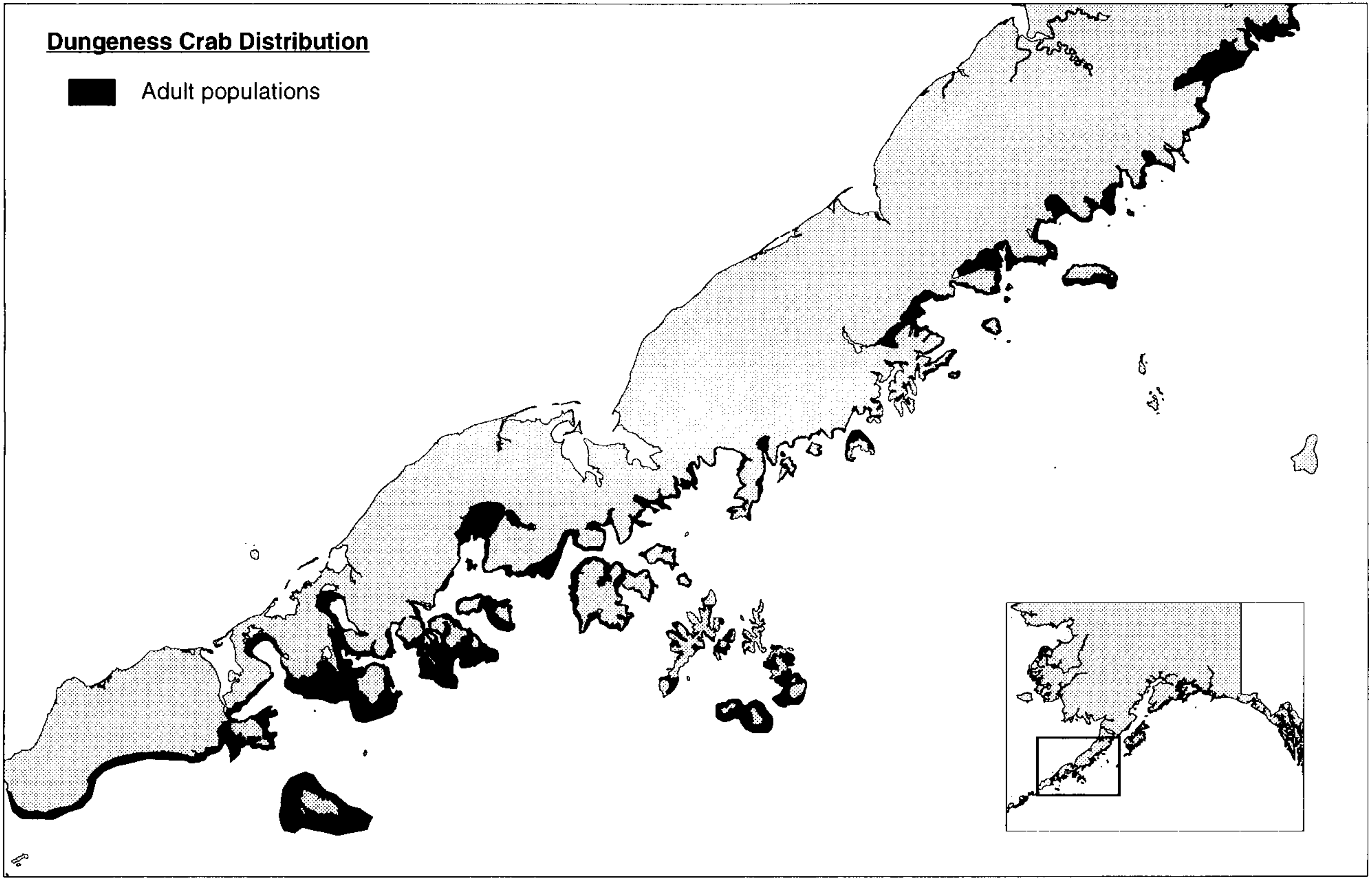
Source: Tim Koeneman, pers. comm,



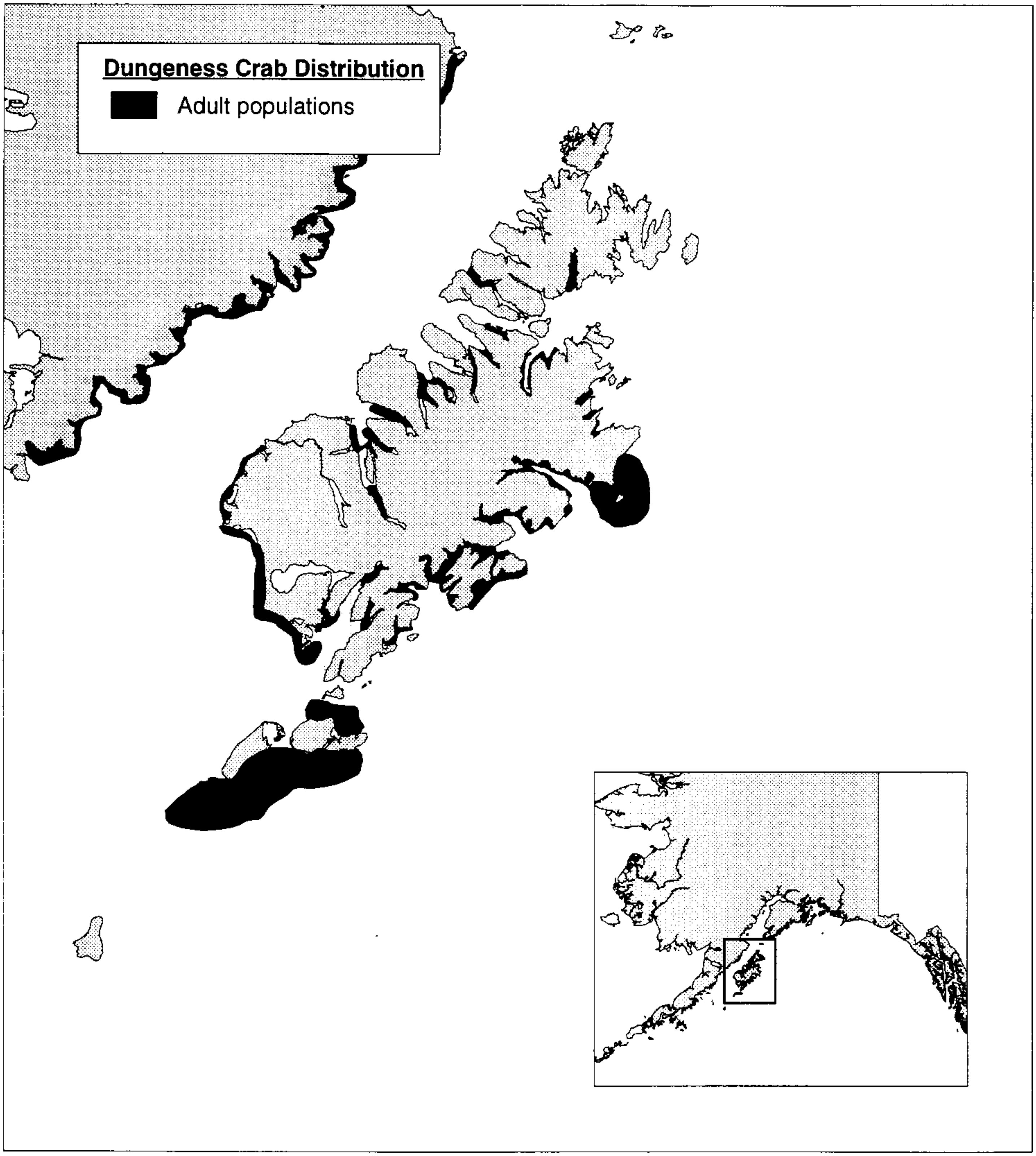
Source: ADF&G Fishticket database, Huges 1981, Dave Jackson and Charles Trowbridge, pers. comm, U.S. Dept. of Commerce, 1990.



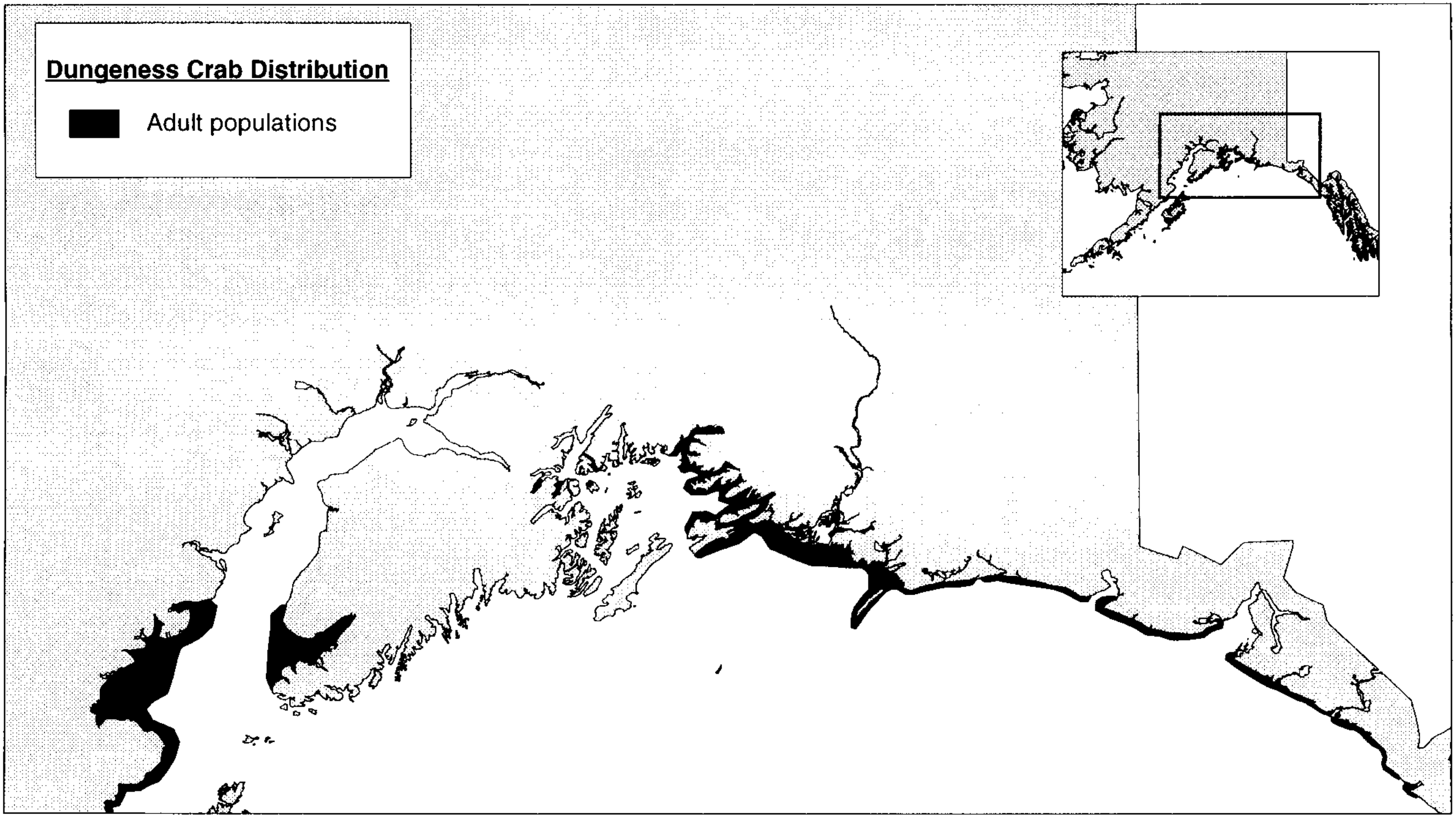
Source: ADF&G Fishticket database, Huges, 1981, Tim Koeneman, pers. comm, U.S. Dept. of Commerce, 1990.



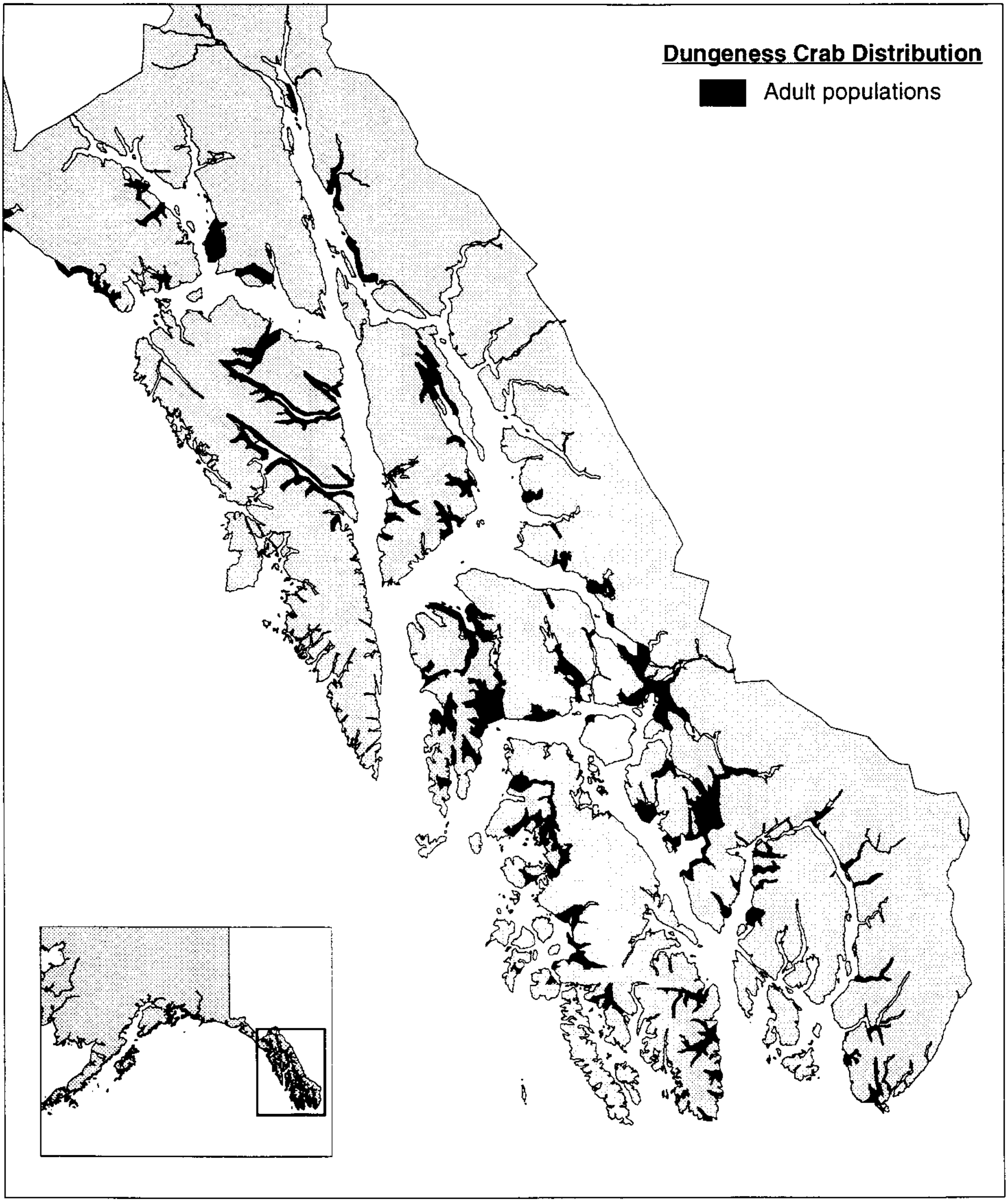
Source: ADF&G Fish Ticket Database, David Jackson and Al Spalinger, pers. comm.



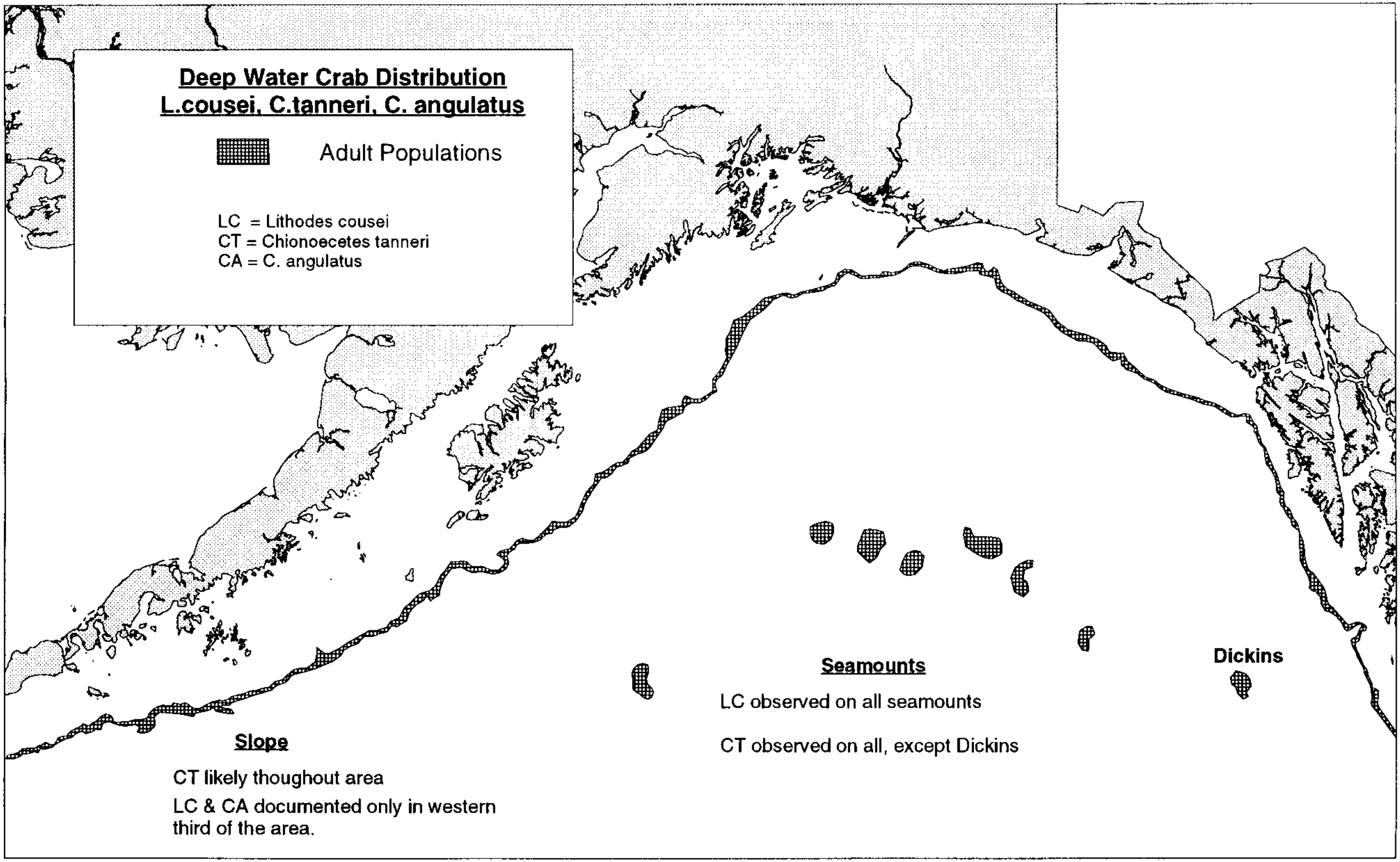
Sources: Al Spalinger and Dave Jackson, pers.comm.



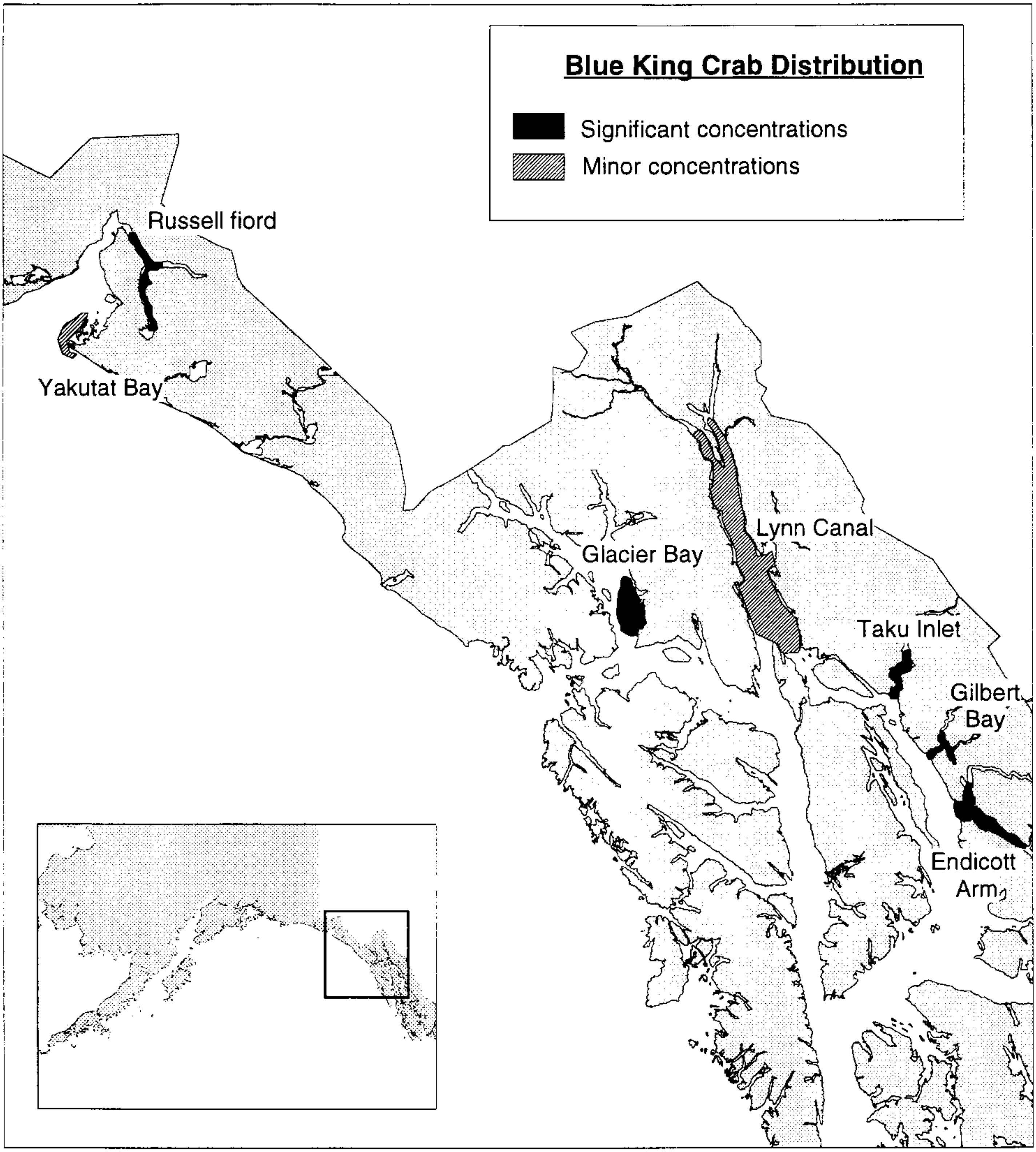
Source: Tim Koeneman, Charles Trowbridge, pers. comm, and U.S. Department of Commerce , 1990.



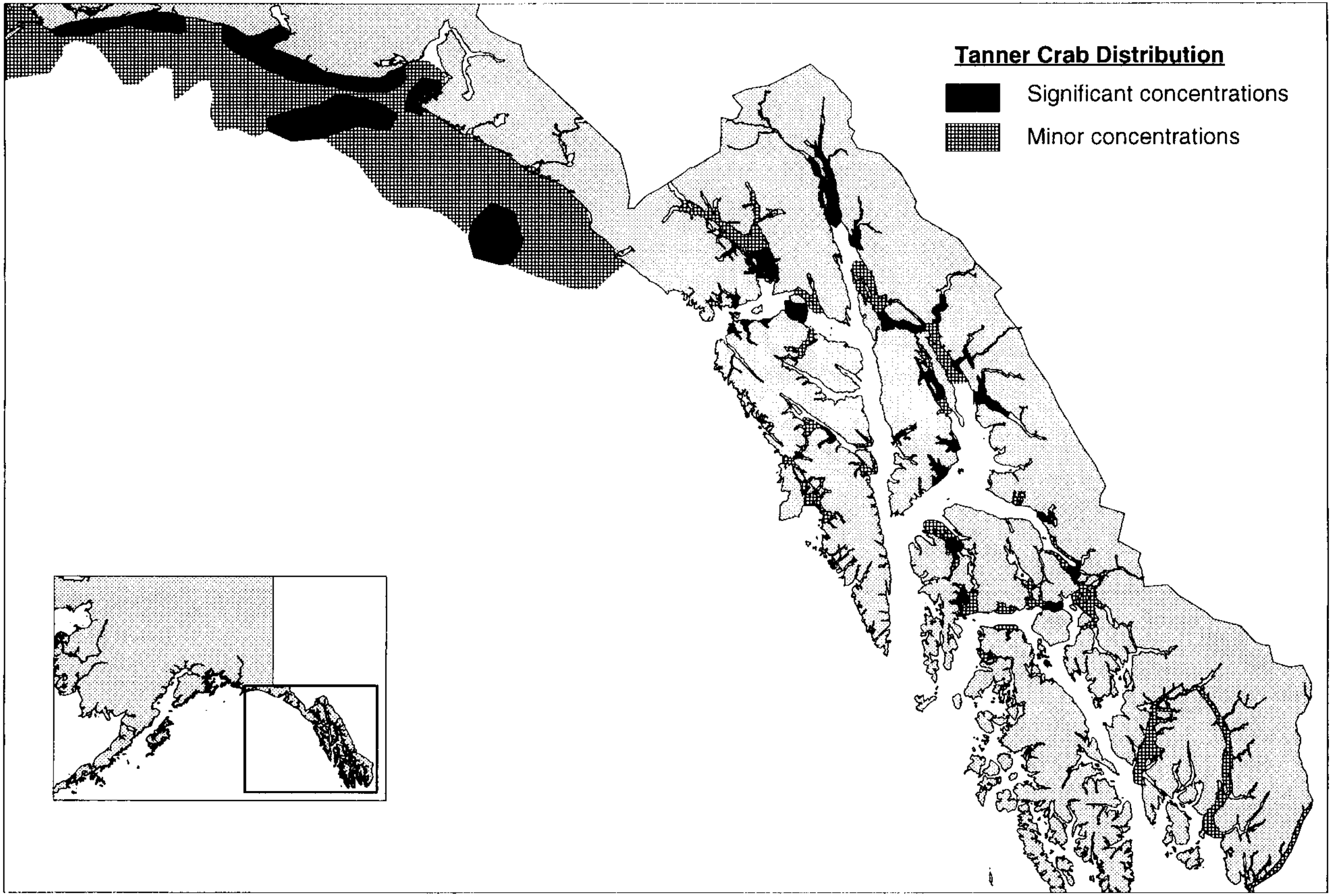
Source: Tim Koeneman, pers. comm.



Source: NMFS Cruise Result No. 79, 1979, ADF&G Observer Database, ADF&G Fish ticket database. Seamount C. tanneri observations may include C. angulatus, D. Somerton, per. comm.



Source: Tim Koeneman, pers. comm.



Source: Tim Koeneman, pers. comm., U.S. Dept. of Commerce, 1990.

9.0 CONSERVATION AND ENHANCEMENT MEASURES

FMPs must describe options to avoid, minimize, or compensate for adverse effects, and promote the conservation and enhancement of EFH, especially in habitat areas of particular concern.

Generally, non-water dependent actions should not be located in EFH if such actions may have adverse impacts on EFH. Activities that may result in significant adverse affects on EFH, should be avoided where less environmentally harmful alternatives are available. If there are no alternatives, the impacts of these actions should be minimized. Environmentally sound engineering and management practices should be employed for all actions which may adversely affect EFH. Disposal or spillage of any material (dredge material, sludge, industrial waste, or other potentially harmful materials) which would destroy or degrade EFH should be avoided. If avoidance or minimization is not possible, or will not adequately protect EFH, compensatory mitigation to conserve and enhance EFH should be recommended. FMPs may recommend proactive measures to conserve or enhance EFH. When developing proactive measures, Councils may develop a priority ranking of the recommendations to assist Federal and state agencies undertaking such measures.

FMPs should provide a variety of options to conserve or enhance EFH, which may include, but are not limited to:

(A) Enhancement of rivers, streams, and coastal areas. EFH located in, or influenced by, rivers, streams, and coastal areas may be enhanced by reestablishing endemic trees or other appropriate native vegetation on adjacent riparian areas; restoring natural bottom characteristics; removing unsuitable material from areas affected by human activities; or adding gravel or substrate to stream areas to promote spawning. Adverse effects stemming from upland areas that influence EFH may be avoided or minimized by employing measures such as, but not limited to, erosion control, road stabilization, upgrading culverts, removal or modification of operating procedures of dikes or levees to allow for fish passage, structural and operation measures at dams for fish passage and habitat protection, or improvement of watershed management. Initiation of Federal, state, or local government planning processes to restore watersheds associated with such rivers, streams, or coastal areas may also be recommended.

(B) Water quality and quantity. This category of options may include use of best land management practices for ensuring compliance with water quality standards at state and Federal levels, improved treatment of sewage, proper disposal of waste materials, and providing appropriate in-stream flow.

(C) Watershed analysis and planning. This may include encouraging local and state efforts to minimize destruction/degradation of wetlands**,** restore and maintain the ecological health of watersheds, and encourage restoration of native species. Any analysis of options should consider natural variability in weather or climatic conditions.

(D) Habitat creation. Under appropriate conditions, habitat creation (converting non-EFH to EFH) may be considered as a means of replacing lost or degraded EFH. However, habitat conversion at the expense of other naturally functioning systems must be justified within an ecosystem context.

The following sections of this EA analysis discuss and evaluate ways to avoid, minimize, or compensate for adverse effects, and promote the conservation and enhancement of EFH, especially in habitat areas of particular concern. Additional options to protect essential fish habitat will be proposed and analyzed in the future. Enhancement, restoration, and habitat creation programs may also be established. Potential impacts from non-fishing activities are monitored during the NMFS and State of Alaska permit review process, and development of habitat computer databases and GIS location maps will greatly assist this process.

9.1 Identification of Non-Fishing Activities Affecting EFH

9.1.1 Guidance from the Interim Final Rule

FMPs must be amended to identify activities that have the potential to adversely affect EFH quantity or quality, or both. Broad categories of activities which can adversely affect EFH include, but are not limited to: Dredging, fill, excavation, mining, impoundment, discharge, water diversions, thermal additions, actions that contribute to non-point source pollution and sedimentation, introduction of potentially hazardous materials, introduction of exotic species, and the conversion of aquatic habitat that may eliminate, diminish, or disrupt the functions of EFH. An FMP should describe the EFH most likely to be adversely affected by these or other activities. For each activity, the FMP should describe known and potential adverse impacts to EFH. The descriptions should explain the mechanisms or processes that may cause the adverse effects and how these may affect habitat function. A GIS or other mapping system should be used to support analyses of data. Maps geographically depicting impacts identified in this paragraph should be included in an FMP.

To the extent feasible and practicable, FMPs should analyze how fishing and non-fishing activities influence habitat function on an ecosystem or watershed scale. This analysis should describe the ecosystem or watershed; the dependence of the managed species on the ecosystem or watershed, especially EFH; and how fishing and non-fishing activities, individually or in combination, impact EFH and the managed species, and; how the loss of EFH may affect the ecosystem**.** An assessment of the cumulative and synergistic effects of multiple threats, including the effects of natural stresses (such as storm damage or climate-based environmental shifts), and an assessment of the ecological risks resulting from the impact of those threats on the managed species' habitat should also be included. For the purposes of this analysis, cumulative impacts are impacts on the environment that result from the incremental impact of an action when added to other past, present, and reasonably foreseeable future actions, regardless of who undertakes such actions. Cumulative impacts can result from individually minor, but collectively significant actions taking place over a period of time.

Essential fish habitat can be significantly altered by direct, cumulative, and/or environmental impacts. Direct impact to a defined essential fish habitat (EFH) will result in loss of its ability to provide specific habitat for a species. Loss of EFH will reduce the species ability to reproduce, survive, or exist. A cumulative impact can be minor, but if not monitored will contribute to the significant alteration of EFH over time. Equally important is an environmental impact which can also contribute to the loss of EFH.

9.1.2 Identification of Non-fishing Adverse Impacts to EFH in Alaska

An ***Adverse Impact***, by definition, means any impact which reduces quality and/or quantity of Essential Fish Habitat (EFH). A reduction of quality and/or quantity of EFH can be described by a direct, cumulative, and/or natural adverse impact. A ***direct impact*** to a defined essential fish habitat will result in loss of its ability to provide specific habitat for a species. ***Cumulative impacts*** are linked to the quantity and location of impacts within a given geographic area. For the purposes of this analysis, cumulative impacts are impacts on the environment that result from the incremental impact of an action when added to other past, present and reasonable foreseeable future action or threat[1], regardless of who undertakes such action. Impacts like these can build on one another, especially in developed areas or communities. Equally important are ***natural adverse impacts***, such as storm damage or climate-based

[1] See attached **Non-fishing Adverse Impacts to Habitat** worksheet. The worksheet is an professional interpretative summary of broad category threats that are described in further detail throughout the Non-fishing Adverse Impacts Section.

environmental shifts, that can also contribute to the loss of EFH. Significant loss of EFH will reduce the species ability to reproduce, survive, or exist.

Species dependent on coastal areas during various stages of their life, particularly during juvenile rearing and adult reproduction, are more vulnerable to habitat alterations than are species that remain offshore. Also, the effects of habitat alteration on offshore species are not as apparent as they are in coastal areas. Concern is warranted, however, to the degree that (1) the offshore environment is subject to habitat degradation from either inshore activities or offshore uses, and (2) to the extent that some species living offshore depend directly or indirectly on coastal habitats for a critical life stage such as reproduction or as a source of food.

This section discusses types of activities that have a potential to cause habitat degradation that could affect fishery populations. This discussion is designed to identify those areas of uncertainty that may reasonably deserve attention in the future and not to be a conclusive review of impacts to EFH. Whether the likelihood and level of these activities or events cause harm to species habitats can be decided when the details of a proposed activity's location, magnitude, timing, and duration are more fully known. At present, human activities that adversely affect habitats are found near commercial fishing efforts, industrial growth areas, and community developments.

Dredging, Fill, Excavation

Potential impacts: excavation and maintenance of channels (includes disposal of excavated materials); construction of ports, mooring and cargo handling facilities; construction and operation of ship repair facilities; and construction of channel stabilization structures such as jetties and revetments.

Specific projects involving offshore marine disposals may directly impact EFH by overburdening and covering marine habitats. Because of the desirability of finding protection from Bering Sea storms, suitable port development sites often are valuable to the fishery fleet infrastructure. Recently, once such project in King Cove, Alaska, potentially could impact 20+ acres of marine habitat. This site was investigated and found not to be EFH for two species of crab, nevertheless the impact warranted investigation. Construction of a port facilities are planned for the City of Nome, Sand Point, and St. Paul, Alaska. In other areas, shallow water depth requires construction of long structures projected seaward in order to provide direct access from the uplands to deeper-draft ocean going vessels. These causeways alter the physical processes of the shoreline such as currents and disruption of fish migration. Another project in the village of Unalaska, required an extension of the airport runway into water depths approximately 50-feet, and received the necessary permits for construction. Beyond these specific projects, development activity in the coastal areas of the Bering Sea and the Aleutian Islands has been largely limited to construction of erosion control measures and breakwaters (e.g., the city of Bethel). As human population increase, so will the desire to have new harbor developments. In Alaska, there are over 40 known Ports of Call. Many villages lack large enough harbors for trade and therefore are not a port. All these require routine dredging ranging from 1-20 year intervals.

From a broad perspective, the environmental effects of dredging can include:

- Direct removal/burial of organisms as a result of dredging and placement of dredged material.
- Turbidity/siltation effects, including increased light attenuation from turbidity.
- Contaminant release and uptake, including nutrients, metals, and organics.

- Release of oxygen consuming substances.

- Noise disturbance to aquatic and terrestrial organisms.

- Alteration to hydrodynamic regimes and physical habitat.

Port expansion has become an almost continuous process due to economic growth, competition between ports, and significant increases in vessel size. Elimination or degradation of aquatic and upland habitats are commonplace since port expansion almost always requires the use of open water, submerged bottoms, and riparian zones. Ancillary port related activities and development often utilize even larger areas, many of which provide water quality and other functions needed to sustain living marine resources. Vessel repair facilities utilize highly toxic cleaners, paints, and lubricants that can contaminate waters and sediments. Modern pollution containment and abatement systems and procedures can prevent or minimize toxic substance releases; however, constant and diligent pollution control efforts must be implemented.

Even with the use of approved practices and disposal sites, ocean disposal of dredged materials is expected to cause environmental harm since contaminants will continue to be released, productive bottoms will still be filled, and localized turbidity plumes and reduced oxygen zones will persist. Dredging discharge increases turbidity and sediment--this is considered by some to be the most prevalent form of pollution in Alaska waters (Lloyd et al. 1987) and has contributed to the absence of grayling in some streams (LaPerriere et al. 1985). The effects of new disposal techniques such as creation of near shore berms and such "beneficial uses" of dredged material as creation of shallow water habitats and emergent wetlands are, in many cases, unclear and resulting long-term geomorphological and ecological change could be harmful to certain species and environments.

Return of materials dredged from the ocean to the water column is considered a discharge activity. Depending upon the chemical constituency of the local bottom sediments and any alterations of dredged materials prior to discharge, living marine resource in the area may be exposed to elevated levels of heavy metals. For example, scallop populations are vulnerable to pollution, even in offshore habitats where dumping and runoff can have an effect (Gould and Fowler 1991). Ocean dumping of sediments mat bury or damage scallops by abrasion and gill clogging (Larsen and Lee 1978). Scallops are efficient at concentrating PCB's and heavy metals, including silver, copper, and nickel (Pesch et al. 1979), mercury (Klein and Goldberg 1970), cadmium (Vattutone et al. 1976), chromium (Mearns and Young 1977). At certain levels of concentration, heavy metals can be lethal or have adverse effects at lesser concentrations. Sublethal concentrations of copper produced substantial kidney and gonad damage in sea scallops, whereas cadmium induced hormonal changes such as early gonad maturation (Gould et al. 1985).

Natural deposits of mercury are know to occur in marine bottom sediments. The levels of mercury in Norton Sound (Nelson et al. 1975) exceed the 3.7 ug/l set by the EPA Marine Quality Standards as the maximum allowable concentration. Wood (1974) demonstrated that mercury available to the aquatic environment in any form can result in steady-state concentrations of methyl, dimethyl, and metallic mercury through microbial catalysis and chemical equilibrium. Large-scale gold dredging projects in eastern Norton Sound will result in the discharge and resuspension of sediments that could introduce mercury to the water column.

Marine Mining

Potential impacts include: removal of substrates that serve as habitat for fish and invertebrates; creation (or conversion) of habitats to less productive or uninhabitable sites such as anoxic holes or silt bottom; burial of productive habitats in the vicinity of the mine site or in near shore disposal sites (as in beach nourishment); release of harmful or toxic materials either in association with actual mining, or in connection with machinery and materials used for mining; creation of harmful turbidity levels; adverse modification of hydrologic conditions so as to cause erosion of desirable habitats.

Mining activity, such the extraction of gravel and gold in the Bering Sea, and placer mining spread throughout the state, can lead to the direct loss of EFH for certain species. Gravel is obtained by mining gravel beaches along the Bristol Bay coast (e.g., Goodnews Bay, Kangirlvar Bay) and in the lower reaches of the Yukon and Kuskokwim Rivers. Mining of large quantities of beach gravel can significantly affect the removal, transport, and deposition of sand and gravel along shore, both at the mining site and down current. During mining, water turbidity increases and the resuspension of organic materials could affect less motile organisms (i.e., eggs and recently hatched larvae) in the area. Benthic habitats could be damaged or destroyed by these actions. Neither the future extent of this activity nor the effects of such mortality on the abundance of marine species is known.

Dredging for gold has been attempted at various sites along the Aleutians and the world's largest mechanical dredge was operated offshore near the city of Nome. A similar proposal, which has received all of the necessary permits to proceed, will entail dredging 21,000 acres of sea bottom in Norton Sound for the purpose of recovering gold. Such activity has the potential to cause physical damage directly and indirectly to benthic habitat, juvenile fish, and adult life stages.

Mining practices that can impact EFH include physical and chemical impacts from intertidal dredging and chemicals such as flocculates. However, tailings and discharge waters from settling ponds can result in loss of EFH and life stages of managed species. Placer mining can introduce levels of heavy metals and arsenic that are naturally found within the stream bed sediments. The impact degrades the water quality and levels can become high enough to prove lethal.

The number of individual mining operations for a given area must be monitored. For instance, three mining operations in an intertidal area could impact EFH, whereas one may not. Also, disturbance of previously contaminated mining areas threaten an additional loss of EFH.

Fish Processing Waste - Shoreside and Vessel Operation

Potential impacts include: direct and/or non-point source discharge of nutrients, chemicals, fish by-products, and stick water; overburdening of original habitats; particle suspension.

Discharge of fish waste from shoreside and vessel processing has occurred in marine waters since the 1800's. The discharge can cause water quality problems. Although all fish waste is biodegradable, including heads, viscera, and bones, fish parts that are ground to fine particles may remain suspended for some time. Also, "stick water,"a byproduct of processing fish meal, takes the form of a fine gel or slime which can concentrate on surface waters and move onshore to cover intertidal areas. Crab and fish have been processed for years in various Alaskan ports including Kodiak, Dutch Harbor, St. Paul, and Akutan, with little impact on habitat for crab and other species. However, localized damage to benthic environment consisting of up to several acres of bottom being driven anoxic by rotting processing waste and piles of waste up to 26 feet deep have been recorded. Processors discharging fish waste are required to have National Pollutant Discharge Elimination System (NPDES) permits from the Environmental

Protection Agency. At-sea floating processors are covered by a general NPDES permit which requires that processing waste be ground into finer than one-half inch particles and discharged below the surface.[2]

Although seafood has been processed at sea by foreign fishing vessels in the past without apparent harm to the marine habitat, there has been one instance reported of unusual quantities of fish carcasses (not ground in conformance with the general NPDES permit) accompanied by dead scallops brought up in scallop dredges (Capt. Louie Audet, F/V Shayline Nicholas). It will be important to be alert to similar possible perturbations of the environment resulting from at-sea processing discharges.

Over time, suspended particles will accumulate. Juvenile and adult stages of flatfish are drawn to these areas for food sources. One effect of this attraction may lead to increased predation on juvenile fish species by other flatfishes, diving seabirds, and marine mammals drawn to the food source. However, due to the difficulty in monitoring these outfalls, impacts to species can go undetected.

Fish waste disposal at marinas can also degrade water quality where large numbers of fish are landed and cleaned, or where fish landings are limited but water circulation is poor (USEPA 1993). In sufficient quantity, fish waste disposal can cause dissolved oxygen depression, contamination, and odor problems in coastal waters (USEPA 1993).

Timber Harvest

Potential impacts include: increase in bedload suspended sediments and turbidity from construction of logging roads, in-water stream crossings, exposed slope erosion, removal of streamside vegetation; alter streamflow; introduce excessive nutrients, decrease large woody debris; increase streambank erosion; alter temperature, and have toxic effects on biota.

Forest road construction can destabilize slopes and increase erosion and sedimentation. This erosion occurs in two forms, as mass soil movement (i.e., landslides) and as surface erosion. Both types can introduce debris and sediment into adjacent streams for many years after initial construction. Erosion is most severe where poor construction practices are allowed, inadequate attention is paid to proper road drainage, and where construction occurs in inclement weather. After construction, unpaved logging roads can be a chronic source of sediment to streams. Juvenile salmon avoid habitat areas with suspended sediment (Bisson and Bilby 1982)

Stream crossings by forest roads may block fish migration. Culverts are often installed as an economical alternative to bridges, although bridges are usually less disruptive to the stream environment. Culverts are a serious threat to salmon unless specifically designed, installed, and maintained to accommodate fish passage.

Removal of streamside vegetation during timber harvest activities increases solar radiation to the stream and results in warmer water during summer, especially in small streams. The magnitude of temperature change depends on the amount of timber harvested adjacent to the stream (Meehan et al, 1969; Brown and Krygier, 1970) and time for regrowth of riparian areas. In Southeast Alaska, Meehan et al., (1969) found that maximum temperature in logged streams exceeded those of unlogged control streams by up to 5ºC, but the temperature did not reach lethal levels. The increased water temperature, however, frequently exceeded the optimum for pink and chum salmon documented by Reiser and Bjornn (1979).

[2] Pers. comm., Dr. Bruce Duncan, U.S. Environmental Protection Agency, 701 C Street, Box 19, Anchorage, AK 99513)

High summer air temperature has been associated with adult salmon mortality. The Alaska Department of Fish and Game compiled a list of 43 streams that had mortality of pink and chum salmon in 1977 associated with high water temperature and low flow. The largest clear-cut in Alaska is located in the Staney Creek watershed. In 1979, 15,000 pink salmon died there before spawning, a result of warm water and low oxygen. In northern areas, the removal of riparian vegetation may cause lower stream temperature during winter, increasing the formation of frazil and anchor ice.

By removing vegetation, timber harvest temporarily reduces transpiration losses from the watershed, thereby elevating water content of soil and increasing run-off during base-flow periods. The elevated water content can reduce soil strength and destabilize slopes, causing increased sediment and debris inputs to streams (Swanston 1974). Sediment deposition in streams can reduce benthic community production (Culp and Davies, 1983) and can cause mortality of incubating salmon eggs and alevins, and habitat loss for juvenile salmon (Heifetz et al. 1996). Cumulative sedimentation from logging activities can significantly reduce the egg-to-fry survival of coho and chum salmon (Cederholm et al. 1981; Cederholm and reid 1987; Hartman et al. 1987). Where egg-to-fry survival is impaired by habitat deterioration escapement goals may have to be increased to offset the effect of decreased spawning success.

Converting large portions of old-growth forests to rapidly growing second-growth forests can permanently reduce summer stream flows and thus permanently reduce salmonid production (Myren and Ellis, 1984). The studies of streams in second-growth forests have demonstrated that the input of large, potentially stable debris (logs and stumps) into salmon habitat from second-growth is reduced relative to inputs from old growth stands (Bisson et al. 1987). Further, the initial high productivity of prey organisms in streams running through open canopy (clear-cut) is short-lived and eventually the quantity of food organisms declines as the canopy closes (Sedell and Swanson, 1984).

Non-point Source Pollution and Urbanization

Potential impacts: direct and/or non-point source discharge of fill, nutrients, chemicals, cooling water, air emissions, and surface and ground waters into streams, rivers, estuaries and ocean waters; conversion of wetlands to sites for residential and related purposes such as roads, bridges, parking lots, commercial facilities; elevation in inorganic and organic nutrient loading in estuarine and coastal waters; coastal development effects to adjacent and downstream ecosystems through modification of the hydrology, chemistry, and biology of streams, lakes, bays, estuaries, and the associated wetlands; and cumulative and synergistic effects caused by association of these and other developmental and non-developmental related activities.

People are moving to the coasts in increasing numbers. A major factor in the threat posed by urban and suburban development is that of non-point source (NPS) discharges of the chemicals used in day to day activities, in operating and maintaining homes and business, for maintaining roads, and for fueling vehicles. Sustainable coastal development from a fishery habitat perspective will need to combine responsible developmental practices at the local and state levels with scientific oversight of environmental conditions in the coastal zone. This can only be accomplished through long-term ecological research and education programs that allow assessment of the combined impacts of exploiting fishery stocks and habitat degradation. The results of such investigations should be used to inform the public and elected officials of the economic and social importance of healthy and productive coastal fishery habitats.

Coastal regions can experience substantial change due to rapid population growth and urbanization. Major point source and non-point source discharges have been linked to industrial/municipal facilities, abandoned hazardous waste sites, and runoff from agriculture and urbanization.   Regional monitoring studies in South Carolina that measured chemical contaminants in surface waters, sediments, and biota indicated linkage between elevated levels of chemical contaminants including polycyclic aromatic hydrocarbons (PAHs) from roadways and marinas and chlordane from housing (Scott et al 1996). Similarly a correlation between elevated levels of coliform bacteria in coastal waters and urbanization was demonstrated (Scott et al 1996).

A consequence of increased human populations is an elevation in inorganic and organic nutrient loading in estuarine and coastal waters. This process can result in transient increased productivity and standing crop of phytoplankton, decreased levels of dissolved oxygen, and shifts in species composition. Higher phytoplankton production and biomass, although potentially beneficial as a food source, may cause decreases in light penetration needed for production by benthic algae, submerged aquatic vegetation and, subsequently, benthic animals. Increased nutrients also can lead to shifts in the species composition of the phytoplankton community where fewer and less desirable organisms may become prevalent. Significant depletion of dissolved oxygen has been shown to occur in association with large algal blooms and significant fish kills have been linked to this process. Nutrient loading has also been linked to noxious algal and dinoflagellate blooms that produce toxins which may be harmful to aquatic organisms and humans. Nutrient loading of scallop populations can cause low dissolved oxygen (hypoxic) conditions (Sindermann 1979), and an increase in bacterial infections (Liebovitz et al. 1984), or algal (Wassman and Ramus 1973) and dinoflagellate blooms (Shumway 1990), all of which can be detrimental to their population.

Urbanization and associated coastal development can effect adjacent and downstream ecosystems through modification of the hydrology, chemistry, and biology of streams, lakes, bays, estuaries, and the associated wetlands. Those aquatic features provide many essential ecological functions including flood and erosion control, diverse biological productivity, and as buffers to physicochemical changes in associated water bodies. Prior to the 1960s, most untreated organic and industrial wastes were dumped directly into streams, lakes or estuaries. Environmental damage from such uncontrolled waste discharge was evident from fish kills, oxygen depletion, massive blooms of nuisance algae, and public health problems. Pacific salmon were most evidently affected by pollution from raw sewage, pulp mill effluents, and acid and metal wastes. Strict regulation of point source discharges of municipal and industrial waste continue to improve that situation. Some toxins from previous unregulated discharges, however, remain trapped in bottom sediments and can be disturbed by current activities.
In urban areas, wetlands are easily degraded or lost by dredging, filling, diking, or draining to provide harbors and building sites. When wetlands are filled, their function of buffering physicochemical changes in adjacent and downstream water bodies is often lost. Development activities can, therefore, have severe impacts on anadromous fish, as well as other wetland-dependant species. Wetlands stabilize hydrology, improve water quality, and increase biological diversity in anadromous fish habitat. Wetlands store and control runoff, thereby decreasing flood peaks and erosion and providing greater base flows in downstream areas. With highly variable runoff, anadromous fish habitat may be eroded during floods and left dry during periods of low runoff. Salmon may be prevented from migrating due to velocity barriers or low water. Spawning areas may be scoured during high water or dry up or freeze during low water. Rearing salmon may be flushed into poor habitat during freshets or trapped in drying areas at low flows. Wetlands can improve water quality as nutrients and pollutants are removed through biological and chemical processes.

Point Source Pollution

Potential impacts include; overburdening of bottom habitat near the location of outfall; degradation; degradation of water quality and habitat from storm water and industrial discharges; pollution effects that may be related to changes in water flow, PH, hardness, dissolved oxygen, and other parameters that affect individuals, populations, and communities; atmospheric pollution dispersal and mixing.

Point source discharges from municipal sewage treatment facilities or storm water discharges are controlled through U.S. Environmental Protection Agency mandated regulations under the Clean Water Act and by state water quality regulations. The primary concerns associated with municipal point source discharges involve treatment levels needed to attain acceptable nutrient inputs and overloading of treatment systems due to rapid development of the coastal zone. Small quantities of industrial and household pollutants have the potential to become large impacts. Storm drains are contaminated from communities with settling and storage ponds, street runoff, harbor activities, and honey buckets. Sewage outfall lines also can significantly alter ph levels of saline waters.

Industrial wastewater effluent is regulated by the U.S. Environmental Protection Agency through the National Pollutant Discharge Elimination System (NPDES) permitting program. This program provides for issuance of waste discharge permits as a means of identifying, defining, and controlling virtually all point source discharges. The complexity and the magnitude of effort required to administer the NPDES permit program limit overview of the program and federal agencies such as the NMFS and the Fish and Wildlife Service generally do not provide comments on NPDES permit notices. For these same reasons, it is not possible to presently estimate the singular, combined, and synergistic effects of industrial (and domestic) discharges on aquatic ecosystems.

At certain concentrations, point source discharges can alter the following properties of ecosystems and associated communities: diversity, nutrient and energy transfer, productivity, biomass, density, stability, connectivity, and species richness and evenness (Carins 1980). At certain concentrations, point source discharges may alter the following characteristics of finfish, shellfish, and related organisms: growth, visual acuity, swimming speed, equilibrium, feeding rate, response time to stimuli, predation rate, photosynthetic rate, spawning seasons, migration routes, and resistance to disease and parasites. In addition to direct effects on plant and animal physiology, pollution effects may be related to changes in water flow, PH, hardness, dissolved oxygen, and other parameters that affect individuals, populations, and communities (Carins 1980). Sewage, fertilizers, and de-icing chemicals (e.g., glycols, urea) are examples of common urban pollutants that decompose with high biological or chemical oxygen demand. Zones of low dissolved oxygen from their decomposition can retard growth of salmon eggs, larvae, and juveniles and may delay or block smolt and adult migration. Sewage and fertilizers also introduce nutrients into urban drainages that drive algal and bacterial blooms which may smother incubating salmon or produce toxins as they grow and die. Thermal effluents from industrial sites and removal of riparian vegetation from streambanks allowing solar warming of water can degrade salmon habitat. Heavy metals, petroleum hydrocarbons, chlorinated hydrocarbons, and other chemical wastes can be toxic to salmonids and their food, and they can inhibit salmon movement and habitat use in streams. Mining, ore processing, smelting, and refining operations often produce heavy metals as waste products that may effect the movement of salmon, causing migration delays. Petrochemicals and chlorinated compounds, such as those in herbicides and pesticides, are toxic or have long-term effects on survival, stamina, and reproduction in salmonids. Peripheral effects of pollution may include forcing rearing fish into areas of high predation or less than optimal salinity for growth.

Contaminants that are emitted into the atmosphere by incinerators, fossil fueled power plants, automobiles, and industry may be transported various distances and directly and indirectly deposited into aquatic ecosystems (Baker et al 1993). As such, the regulation of surface water contamination from atmospheric pollution may require local, regional, and international efforts. Atmospheric linkage of pollutants from local, regional, and remote sources is also possible and, accordingly, the types and levels of contaminants reaching surface waters may vary. Although the magnitude and effect of atmospheric pollution dispersal and mixing may be difficult to assess, it is clear that atmospheric contaminants are routinely deposited in coastal and estuarine waters.

Hazardous Material / General Litter

Potential impacts include: introduction of hazardous and toxic materials from at sea ocean disposal; disposal of contaminated dredged material; illegal dumping of trash, wastewater, and unwanted cargo; accidental disposal of material; "short dumping" of dredged material before permitted disposal area; introduction of general litter such as plastics, derelict fishing gear, and miscellaneous detrital matter.

Under provisions of the Marine Protection Research and Sanctuaries Act (MPRSA), ocean disposal of hazardous and toxic materials, other than dredged materials, is prohibited by U.S. flag vessels and by all vessels operating in the U.S. territorial sea and contiguous zone. The U.S. Environmental Protection Agency (EPA) may issue emergency permits for industrial waste dumping into ocean waters if an unacceptable human health risk exists and no other alternative is feasible. The MPRSA assigns responsibility the ocean disposal of dredged material to the EPA and the U.S. Army Corps of Engineers (COE). This involves: designating ocean sites for disposal of dredged material; issuing permits for the transportation and disposal of the dredged material; regulating times, rates, and methods of disposal and the quantity and type of dredged material that may be disposed of; developing and implementing effective monitoring programs for the sites; and evaluating the effect of dredged material disposed at the sites.

Dumping of trash, wastewater, and unwanted cargo is more likely to occur on the open seas since it is less observable here than in inshore waters. Prior to passage of the Marine Plastic Pollution Research and Control Act (MPPRCA) of 1987 (PL 100-220) an estimated 14 billion pounds of garbage was being dumped into the ocean each year. Of this amount more than 85 percent was believed to have come from the world's shipping fleet in the form of cargo associated wastes.

In the absence of MPRSA and MPPRCA repeal or weakening, major dumping threats to EFH within federal waters should theoretically be limited mostly to illegal dumping and accidental disposal of material in unapproved locations. In reality, the present era of reduced government action and involvement many agencies lack sufficient staff and funds to carry out mandated responsibilities and the opportunity for unobserved illegal and accidental dumping may be substantial. This includes disposal of all types of materials as well as "short dumping" of dredged material whereby dumping takes place between the dredge site and the designated dump site.

The Act to Prevent Pollution from Ships (MARPOL ANNEX V) places limitations on ships to prohibit discharging or depositing any refuse matter, hazardous substance, oil, plastics and dunnage and will lessen impacts to EFH. Persistent plastic debris is introduced into the marine environment from offshore vessels and commercial fisheries, as well as from general shore activities. Debris includes synthetic netting, pots, longline gear, packing bands, and rope. Estimates of debris have been based on observations of debris at sea and on beaches, and occasional reports of accidental or deliberate discards of fishing gear. Studies by Merrell (1984) and others have shown that much of the observed entanglement debris consists of fragments of trawl web. Some trawl web gets discarded overboard following net repair, but most probably gets lost during normal fishing operations (e.g., fishing over rough bottoms, foul weather). Deliberate discharge at sea of all plastics are now prohibited by MARPOL Annex V.

Debris discarded at sea can entangle or be ingested by marine mammals, fish, shellfish, sea birds, and sea turtles. The persistent nature of plastics can pose a hazard to marine life for years. Other lost or discarded gear, such as crab pots continue to fish indefinitely. Neither the extent of debris-related mortality nor population effects on various species are known.

Mariculture and Introduction of exotic species

Potential impacts include: introduction of genetic variance into juvenile and adult populations from hatchery fish stocks; transfer and introduction of exotic and harmful organisms through ballast water discharge.

Mariculture can have adverse effects on habitat because of over-enrichment of water and benthic habitat by uneaten food, feces, or other organic materials (Faris 1987). Accumulations on the bottom can create anaerobic conditions near mariculture sites and degrade foraging areas for juvenile salmon (Phillips et al. 1985). Additional threats include introductions of exotic species or domestic strains which might prey upon, compete with, or interbreed with wild stocks, and the spread of disease from culture facilities. Habitat can also be affected from the development of ancillary facilities, such as access roads, floating processing plants, or caretaker residences.

With recent introduction of the zebra mussel into the Great Lakes and its rapid dispersal into other waters considerable attention is being directed at the introduction of exotic species into U.S. waters via discharge of ship's ballast. According to one estimate (Carlton, 1985) two million gallons of foreign ballast water are released every hour into U.S. waters -- possibly representing the largest volume of foreign organisms released on a daily basis into north American ecosystems. The introduction of exotic organisms threatens native biodiversity and could lead to changes in relative abundances of species and individuals that are of ecological and economic importance. The social and economic implications of zebra mussel introduction into North American waters and the introduction of the comb jelly *Mnemiopsis* into the Sea of Azov in Russia -- which has helped decimate the region's anchovy fishery -- point out the seriousness of this threat.

Oil and Natural Gas Activities

Potential impacts include: elimination or damage to bottom habitat due to drill holes and positioning of structures such as drilling platforms, pipelines, anchors, etc;, release of harmful and toxic substances from extracted muds, oil, and gas; and from materials used in oil and gas recovery; damage to organisms and habitats due to accidental spills; damage to fishing gear due to entanglement with structures and debris; and damage to fishery resources and habitats due to effects of blasting (used in platform support removal); and indirect and secondary impacts to near shore aquatic environments affected by product receiving, processing, and distribution facilities.

Information can be found in Berg (1977); Deis (1984); OCSEAP Synthesis Reports on the St. George Basin (1982), the Navarin Basin (1984), and the North Aleutian Shelf (1984); Thorsteinson and Thorsteinson (1982); and the University of Aberdeen (1978). The Alaska offshore area comprises 74 percent of the total area of the U.S. continental shelf. Because of its size, the Alaska outer continental shelf (OCS) is divided into three subregions—Arctic, Bering Sea, and Gulf of Alaska. Areas where oil and gas leases have occurred or are scheduled in the BSAI area include the Navarin Basin (1989)(Morris, 1981), St. George Basin (1990)(NMFS, 1979), North Aleutian Basin (1990)(NMFS, 1980) and the Shumagin Basin (1992) (Morris, 1987).

If a commercial quantity of petroleum is found, its production would require construction of facilities and all the necessary infrastructure from pipelines to onshore storage and shipment terminals or for building offshore loading facilities. It is believed that Bering Sea oil would be pipelined to shore and then loaded on tankers for transportation from Alaska. In the Navarin Basin, however, offshore-loading terminals may be more feasible. Unlike exploration, production would continue year-round and would have to surmount the problems imposed by winter sea-ice in many areas. Norton Basin and perhaps Navarin

Basin would require ice-breaking tanker capabilities. There are also occasional proposals for tankering oil from Arctic fields via the Bering Sea, which would also require ice-breaking capabilities.

Oil and gas related activities have the potential to cause pollution of habitats, loss of resources, and use conflicts. Physical alterations in the quality and quantity of existing local habitats may occur because of the siting and construction of offshore drilling rigs and platforms, loading platforms, or pipelines.

Accidental discharge of oil can occur during almost any stage of exploration, development, or production on the OCS or in near shore base areas. Oil spills may result from many possible causes including equipment malfunction, ship collisions, pipeline breaks, human error, or severe storms. Oil spills may also be attributed to support activities associated with product recovery and transportation. In addition to crude oil spills, chemical, diesel, and other oil-product spills can occur in association with OCS activities. Of the various potential OCS-related spill sources, the great majority are associated with product transportation activities (USDOI, MMS, 1996).

The 1989 *Exxon Valdez* oil spill in Prince William Sound, the largest oil spill ever in U.S. waters, contaminated 2,000 km of coastal habitat (Spies et al. 1996). It spilled 42 million liters of crude oil which had immediate acute effects and longer-term impacts on fish and wildlife. Beached oil penetrated deeply into cobbled beaches and still persists in some areas beneath the surface layer of rocks and under mussel beds. Contamination of intertidal spawning areas for pink salmon caused increased embryo mortality and possible long-term developmental and genetic damage (Bue et al. in press). Wild pink salmon spawn in intertidal stream deltas, and therefore, are susceptible to marine oil spills. The embryo is a critical stage of salmon development and is vulnerable to pollution because of its long incubation in intertidal gravel and its large lipid-rich yolk which will accumulate petroleum hydrocarbons from low-level, intermittent exposures (Heintz et al., unpub.).

Residual oil from a spill can remain toxic for long periods because the most toxic components are the most persistent. Petroleum is a complex mixture of alkanes and aromatic hydrocarbons, of which the alkyl-substituted and multi-ring polynuclear aromatic hydrocarbons (PAH) are the most toxic and persistent. These large PAH predominate in weathered oil. Because of low solubility in water, the large PAH probably contribute little to acute toxicity of oil-water solutions. Lipophilic PAH, however, may cause physiological injury if they accumulate in tissues after lengthy exposure (Heintz et al., unpub.).

Chronic small oil spills are also a potential problem because residual oil can build up in sediments and affect living marine resources. Low levels of PAH from such chronic pollution can be accumulated in salmon tissues and cause lethal and sublethal effects, particularly at the embryo stage. Demonstrated effects from low-level chronic exposure include increased embryo mortality, reduced marine growth, and increased straying in returning adults.

Many factors determine the degree of damage from an oil spill. The most important variables are the type of oil, size and duration of the spill, geographic location, season, and oceanographic conditions. Habitats most sensitive to oil pollution are typically located in coastal areas with low physical energy (e.g., estuaries, tidal marshes). Exposed rocky shores and ocean surface waters are high-energy environments where physical processes more rapidly remove spilled oil. Benthic and scallop species can also be affected by oil spills, via decreased gill respiration, but the effects are considered to be sort lived (Gould and Fowler 1991). Spiny scallops were found to be moderately sensitive to acute exposures (96 hour) to Cook Inlet crude and No. 2 oil (Rice et al. 1979).

After a large spill, aromatic hydrocarbons would generally be at toxic levels to some organisms within this slick. Beneath and surrounding the surface slick, there would be some oil-contaminated waters.

Vertical mixing and current dispersal acts to reduce the oil concentrations with depth and distance. If the oil spill trajectory moves toward land, habitats and species could be affected by the loading of oil into contained areas of the near shore environment. In the shallower waters, an oil spill could be mixed by wave action throughout the water column and contaminate subtidal sediment. Suspended sediment can also act to carry oil to the seabed. In the *Exxon Valdez* oil spill, 13% of spilled oil was deposited in subtidal sediments where it was available to deposit-feeding organisms (Spies et al. 1996).

Oil mixed into bottom sediments persists for years and becomes a long term source of low level pollution. Cold temperature slows the evaporation biodegradation processes, so toxic hydrocarbons persist longer. Oil can also be trapped by ice. Toxic aromatic fractions mixed to depth under the surface slick could cause mortalities and sublethal effects on salmon.

Tainting of salmon and fishing gear flesh is a potential problem in areas subject to either chronic or acute oil pollution. The *Exxon Valdez* oil spill, for example, caused the closure of fisheries for black cod, shrimp, herring,
and salmon. Although sockeye salmon were not directly affected by the spill, the fishery in upper Cook Inlet was closed to forestall fouling of gear and public perception of tainting. The sockeye fishery closure caused over-escapement to some freshwater spawning and rearing lakes and subsequent poor production of fry and smolts.

Large oil spills are the most serious potential source of oil and gas development-related pollution. Offshore oil and gas development will inevitably result in some oil entering the environment. Most spills are expected to be of small size, although there is a potential for large spills to occur. Chronic oil spills which build up in the sediments around rigs and facilities are also a problem. In whatever quantities, lost oil can affect habitats and living marine resources. Many factors determine the degree of damage from a spill; the most important variables are the type of oil, size and duration of the spill, geographic location of the spill, and the season. Although oil is toxic to all marine organisms at high concentrations, certain species are more sensitive than others. In general, the early life stages (eggs and larvae) are most sensitive; juveniles are less sensitive, and adults least so (Rice, et al. 1984).

Habitats most sensitive to oil pollution are typically located in those coastal areas with the lowest physical energy because once oiled, these areas are the slowest to repurify. Examples of low energy environments include tidal marshes, lagoons, and seafloor sediments. Exposed rocky shores and ocean surface waters are higher energy environments where physical processes will more rapidly remove or actively weather spilled oil.

It is possible for a major oil spill (i.e., 50,000 bbls) to produce a surface slick covering up to several hundred square kilometers of surface area. Oil would generally be at toxic levels to some organisms within this slick.. Beneath and surrounding the surface slick, there would be some oil-contaminated waters. Mixing and current dispersal would act to reduce the oil concentrations with depth and distance. If the oil spill trajectory moves toward land, habitats and species could be affected by the loading of oil into contained areas of the near shore environment. In the shallower waters, an oil spill could be mixed throughout the water column and contaminate the seabed sediments. Suspended sediment can also act to carry oil to the seabed. It is believed up to 70 percent of spilled oil may be incorporated in seafloor sediments where it is available to deposit feeding organisms (crab) and their prey items.

Toxic fractions of oil mixed to depth and under the surface slick could cause mortalities and sublethal effects to individuals and populations. However, the area contaminated would appear negligible in relation to the overall size of the area. For example, Thorsteinson and Thorsteinson (1982) calculated that a 50,000 barrel spill in the St. George Basin would impact less than 0.002 percent of the total size of this area. Even if concentrations of oil are sufficiently diluted not to be physically damaging to marine organisms or their consumers, it still could be detected by them, and alter certain behavior patterns. If an oil spill reaches near shore areas with productive nursery grounds or areas containing high densities of fish eggs and larvae, a year class of a commercially important species of fish or shellfish could possibly be reduced, and any fishery dependent on it may be affected in later years. An oil spill at an especially important habitat (e.g., a gyre where larvae are concentrated) could also result in disproportionately high losses of the resource compared to other areas. Additional concern is the unknown impact of an oil related event near and/or within ice. The water column adjacent to the ice edge is stable. This stabilization (or stratification) would allow relatively quick transport of oil to the seafloor. Additionally, oil trapped in ice could impact habitat significantly after the initial event, months or years later, and even into a different region or country.

Other sources of potential habitat degradation and pollution from oil and gas activities include the disposal of drilling muds, fluids, and cuttings to the water and seabed, and dredged materials from pipeline laying or facilities construction. Naturally occurring sediments or introduced materials may contain heavy metals or other chemical compounds that would be released to the environment, but the quantities are generally low and only local impacts would be expected to occur.

Areas that are currently and historically influenced by oil and gas production operation facilities: Arctic Ocean/ North Slope, Chukchi Sea, Bering Sea/Navarin Basin, Gulf of Alaska/Yakutat Basin, Cook Inlet, and Prince William Sound.

Hydroelectric Projects, Dams and Impoundments

Potential impacts include: detrimental effects on salmon and their habitat; transformation of a river from its natural free-flowing state to an impoundment fundamentally alters that environment; decline or loss of original species; change in temperature regime; change in circulation and flow patterns.

Dams are a significant barrier to upstream and downstream migrations of salmon, and have probably caused the greatest loss of salmon habitat due to human activities in the lower 48 states. Dependence on technology to provide passage around dams has seldom been successful. Fishway design and flow are important to attract and guide adult salmon into passage facilities. Poorly designed fishways can inhibit upstream movement of adults, causing migration delays, increased pre-spawning mortality, and reduced reproductive success in fish that eventually reach their spawning grounds (U.S. Bureau of Reclamation 1985; Hallock et al. 1982). Dams also present obstacles to downstream passage of juveniles, and passage through turbines or over spillways can result in migration delays, increase predation, and direct mortality.

Major adverse effects on salmon stocks and habitat caused by dams have been avoided or mitigated in Alaska, as managers have learned from mistakes made in the lower 48 states. A more complete discussion of effects of dams on salmon can be found in the Habitat Appendix of the Eighth Amendment to the Fishery Management Plan for Commercial and Recreational Salmon Fisheries off the Coasts of Washington, Oregon, and California Commencing in 1978 (PFMC 1987).

Existing Federal Energy and Regulatory Commission (FERC) hydroelectric projects within Alaska include (Name Project #): Beaver Falls (# 01922), Black Bear Lake (#10440), Blind Slough (#00201), Blue Lake (# 02230), Bradley Lake (#08221), Burnett River Hatchery (#10773), Chignik (# 00620), Cooper Lake (#02170), Dry Spruce (# 01432), Goat Lake (# 11077), Green Lake (#02818), Humpback Creek (#08889), Jetty Lake (#03017), Ketchikan Lakes (#00420), Pelican (#10198), Power Creek (#11243), Salmon Creek (#02307), Skagway-Dewey Lakes (#01051), Solomon Gulch (# 02742), Swan

Lake (#02911), Terror Lake (#02743), Tyee Lake (#03015). Recent interests for new projects include: Twin Lake and Old Harbor on Kodiak Island; Silver Lake and Power Creek in Prince William Sound.

FERC projects can have concerns regarding upstream and downstream passage; provision of adequate instream flow regimes for spawning, rearing, and migration; maintenance of water quality for anadromous fish. Each of these areas is discussed below.

Fish passage for both upstream and downstream migrating salmon, steelhead, and other anadromous fish must be provided to avoid delay, injury, and excessive stress. Required passage facilities must be installed during project construction and must be operated at all times that fish are present. In order to satisfy these objectives, it is necessary to develop a proposal for fish passage facilities. The proposal should define type, location, size, method of operation, and other pertinent facility characteristics. It should reflect state and federal fisheries agency input and design criteria.

Upstream passage facilities are generally required at any project feature which impairs natural passage conditions. At some projects this may require a fish collection system with fishway entrances correctly located and adequate attraction flows, a fish ladder, and an exit structure to return adults to the stream at an appropriate location upstream from the project. At other projects, less extensive facilities are required depending upon the degree of passage obstruction and other site-specific characteristics.

For downstream migrating juveniles, the basic need is to screen turbine intakes to prevent the fish mortalities associated with passage through the turbines by excluding fish from the intake flow. Requirements concerning screen areas and mesh sizes must be satisfied to assure acceptable operation. A bypass flow to safely carry fish from in front of the screens to an appropriate location below the project is a fundamental need. Frequently a system of ports and bypass pipes is necessary. Passage facilities must be designed and maintained to function properly through the full range of flows normally occurring during fish migration periods.

Construction impacts include: siltation of spawning gravels; timing; temperature elevation or reduction which may cause reduced fish growth or disease; gas super-saturation which may occur due to plunging water and result in fish gas-bubble disease; reservoirs which tend to be nutrient traps may cause decreased fish production downstream by reducing available food supplies; silt-laden reservoir releases which decrease invertebrate production and salmon egg survival.

Construction and operation of the project without fishery considerations could result in an interruption/diversion of water supply to and degradation of water quality. The interruption/diversion could be in terms of destruction of incubating eggs, alevins, and fry in the system. Disrupted flows and/or water quality could also result in alteration of migration and spawning habitat. Construction of the dam, powerhouse, and penstock structures could increase turbidities downstream with potential impacts to migration, spawning and rearing of salmon. Construction of the dam, powerhouse, and penstock structures could also result in erosion and increased input of particulate matter into the creek with adverse impacts to migration, spawning, incubation, and rearing salmon.

Adequate flow regimes and water quality are critical for anadromous fish. Consequently, flow regimes and water quality sufficient for successful spawning, incubation, rearing, and migration must be established and maintained through and downstream of project area where needed. If flow reduction, diversion, or modification of flow regimes are anticipated in the operation scenario for the project, anadromous fisheries could be adversely affected not only in the immediate project area but in the entire system downstream of the facility. Examples of this include the diversion of water from the creek/river to a powerhouse which results in a decrease of water which reaches downstream spawning gravel and rearing habitat and tailrace water discharges that could attract and divert returning adult fish from creek/river, thereby decreasing egg deposition and jeopardizing future returns. To address these matters, flow studies must be performed to determine flow regimes that will conserve and protect stocks of anadromous fish in the river system.

Marine Traffic and Transportation

Potential impacts include: potentially harmful vessel operations activities include, but are not limited to: discharge or spillage of fuel, oil, grease, paints, solvents, trash, wastes (including sanitary discharges), and cargo into coastal and tributary waters; alteration of aquatic habitats by the operation of marinas, piers, and docks; disturbance and damage to living marine resources and their habitats by waves, noise, propellers, water jets and other vessel related operations such as anchoring and grounding; exacerbation of shoreline erosion due to wakes.

Routine vessel traffic, discharges, and accidents are potential threats to EFH. The Far East Trade Route takes vessels north by northwest out of the Straits of Juan De Fuca, across the North Pacific and Gulf of Alaska, then through Unimak Pass, Alaska en route to the Far East. Cargo, bunker sea, tanker, freighter, fishing, and recreational vessels make up the vast fleet that transit these waters. In recent times, the freighter vessel Swallow, tanker vessel Exxon Valdez, and freighter vessel Kiroshima grounded and the resulting oil spills proved lethal to marine life and ecosystems. Oil tug and barge traffic is common and their route transits to the major fueling ports of Unalaska, St. Paul, and other coastal cities. In addition, summer vessel traffic increases in the offshore waters with tug and tow traffic bound for the North Slope developments. Other increased traffic seasons coincide with commercial fishery openings, which usually end with at least one vessel grounding or sinking. EFH loss from hazardous cargo is ever present. Other direct impacts from vessels include pollutants such as raw sewage, bilge oil discharge, plastics, and food wastes.

The chronic effects of vessel grounding, prop scarring, and anchor damage are generally more problematic in conjunction with recreational vessels. While grounding of ships and barges is less frequent, individual incidents can have significant localized effects.

Marinas and other sites where vessels are moored are often plagued by accumulation of anti-fouling paints in bottom sediments, by fuel spillage, and overboard disposal of trash and wastewater. A study of marinas found that they may contribute to increases in fecal coliforms, sediment oxygen demand, and chlorophyll a, and decreases in dissolved oxygen.(NC Department of Environment, Health, and Natural Resources 1990)

In the Coastal Zone Management Act of 1972, as amended, Congress declared it to be national policy that state coastal management programs provide for public access to the coasts for recreational purposes. Clearly, boating and adjunct activities (e.g., marinas) are an important means of public access. When these facilities are poorly planned or managed, however, they may pose a threat to the health of aquatic systems and may pose other environmental hazards (USEPA 1993). Since marinas are located at the water's edge, there is often no buffering of the release of pollutants to waterways. The USEPA (1993) identifies the following adverse environmental impacts as possibly being related to marinas and associated activities:

(1) Pollutants discharged from boats;
(2) Pollutants generated from boat maintenance activities on land and in the water;
(3) Exacerbation of existing poor water quality conditions;

(4) Pollutants transported in storm water runoff from parking lots, roofs, and other impervious surfaces; and
(5) The physical alteration or destruction of wetlands and of shellfish and other bottom communities during the construction of marinas, ramps, and related facilities.

Marina related impacts to aquatic systems include lowered dissolved oxygen, increased temperature, bioaccumulation of pollutants by organisms, water contamination, sediment contamination, resuspension of sediments, loss of SAV and estuarine vegetation, change in photosynthesis activity, change in the nature and type of sediment, loss of benthic organisms, eutrophication, change in circulation patterns, shoaling and shoreline erosion. Pollutants that result from marinas include nutrients, metals, petroleum hydrocarbons, pathogens, and polychlorinated biphenyls (USEPA 1993).

Marina personnel and boat owners use a variety of boat cleaners, such as teak cleaners, fiberglass polish, and detergents and cleaning boats over the water, or on adjacent upland, creates a high probability that some cleaners and other chemicals will entering the water (USEPA 1993). Copper-based antifouling paint is released into marina waters when boat bottoms are cleaned in the water (USEPA 1993). Tributyl-tin, which was a major environmental concern, has been largely banned except for use on military vessels. Fuel and oil are often released into waters during fueling operations and through bilge pumping. Oil and grease are commonly found in bilge water, especially in vessels with inboard engines, and these products may be discharged during vessel pump out (USEPA 1993).

Boats propellers can also impact fish and fish habitat by direct damage to multiple life stages of associated organisms, including egg, larvae, juveniles, and through water column de-stratification (temperature and density), resuspending sediments, and increasing turbidity (Stolpe 1997; Goldsborough 1997).

Grounding tends to be an infrequent occurrence on fishery habitats such as seagrass beds and coral reefs. The degree of damage is related to the size of the grounded vessel. Large vessels that ground in shallow water seagrass beds may cause considerable localized damage especially when propeller force is used break free. Crushing damage is usually minimal. Grounding on coral reefs may cause extensive to the reef structure since most coral is highly susceptible to breakage and crushing, and recovery is slow.

One of the most conspicuous byproducts of boating activity and human occupation of coastal environments is the presence of marine debris or trash in the coastal waters, beaches, intertidal flats, and vegetated wetlands. The debris ranges in size from microscopic plastic particles (Carpenter et al. 1972), to mile-long pieces of drift net, discarded plastic bottles, bags, aluminum cans, etc.

Sewage and other wastes discharged from recreational boats may be most problematic in marinas and anchorage sites where vessels are concentrated. Despite existing federal and state regulations involving discharges of sewage and other materials, detection and control of related activities is difficult and some discharges still occur. According to the 1989 American Red Cross Boating Survey, there were approximately 19 million recreational boats in the United States (USEPA 1993). About 95 percent of these boats were less than 26 feet in length and a large number of these boats used a portable toilet, rather than a larger holding tank. Given the large percentage of smaller boats, facilities for the dumping of portable toilet waste should be provided at marinas that service significant numbers of boats under 26 feet in length (USEPA 1993).

Increased recreational boating activity may contribute significantly to pollution of coastal waters by petroleum products. All two-cycle outboard engines require that oil be mixed with gasoline, either directly in the tank or by injection. That portion of the oil that does not burn is then ejected, along with other exhaust products, into the water.

Natural Adverse Impacts

Potential impacts include potential threats from geophysical and seismic activity such as volcanoes, earthquakes, shelf vents; natural occurring elements such as oil seeps and coal outcrops; coastal and inland storms can cause severe acute and chronic perturbations including habitat erosion, burial by deposition of sediment on deepwater habitats and wetlands; creation of strong currents that alter habitats and remove biota; damage by wind and waves; elevation of turbidity that can cause physiological damage and disrupt feeding, spawning migration, and other vital processes; and abrupt changes in salinity and other water quality characteristics such as fecal coliform levels. Changes in marine habitat may also be the result of the activities of marine animals.

Long-term climatological changes can bring about similar changes by altering weather patters. Large scale ecological changes may also occur where temperature changes favor or harm a particular species or group. Changes that cause relocation of frontal boundaries, weed lines, and stratification and temperature boundaries may also cause substantial and undesirable environmental change These events potentially can eliminate EFH for any species without any indication or warning. Impacts range from alteration of habitat from undersea landslides to introduction of exotic prey species following a favorable current. Events as such can be theorized but hard to foresee and manage.

Ocean-atmospheric physics is hypothesized to cause variation in recruitment of several crab stocks in the North Pacific Ocean and Bering Sea with the decadal shifts in barometric pressure indices, sea level, sea surface temperature and ecosystem conditions (Zeng and Kruse, MS). In years of strong Aleutian Lows, warm incubation temperatures promote crab egg hatching too early to match the spring bloom reducing survival of first feeding larvae. A strong Aleutian Low also promotes a more diverse assemblage of species in the phytoplankton community and adversely effects larvae of red king crab. Wind stress causing advection of very specific stocks of crab larvae may also be important to the crab recruitment process.

The activities of some marine animals also alter benthic habitat. California grey whales "till the soil" when feeding on amphipods. In the Chirikof Basin and the area south of St. Lawrence Island, gray whales created pits averaging 2.5 meters long, 1.5 meters wide, and 10 centemeters deep. Creation of these pites are estimated to suspend 172 million metric tons of sediment a year -- three times the amount of suspended sediment discharged annually by the Yukon River (Nelson and Johnson 1987). Pacific walrus make furrows (averaging 47 meters long, 0.4 meters wide, and 0.1 meters deep) in the benthic habitat while searching for clams and are estimated to disturb around 100 million metric tons of sediment per year (Nelson and Johnson 1987; Sease and Chapman 1988).   Sea otters, by preying on sea urchins, allow kelp beds to increase which increases siltation rates reducing habitat for barnacles, mussels, sea stars and hermit crabs (Palmisano and Estes 1977). Sun stars *(Pycuopodia helianthoides*) using their suckers like conveyor belts are able to dig holes up to 12 inches deep in their search for clams (Mauzen et al. 1968).

Although the issue of global warming is controversial, all models predict some temperature increases, especially in the higher latitudes of the Northern Hemisphere (USDC 1997). According to the U.S. Department of Commerce, significant Arctic warming, particularly after 1920, may be related to increased solar radiation, increased volcanic activity, and other naturally occurring factors (USDC 1997a). Human induced increases in greenhouse gas concentrations combined with natural conditions to cause unprecedented warming in the Arctic in the 20th century and between 1840 and the mid-20th century the Arctic warmed to the highest level in the past four centuries.

Global temperature increases of a degree or two can cause sea level rise if melting of permafrost and ice cap follow. Possible effects include: significant loss of coral reefs, salt marshes, and mangrove swamps that are unable to keep up with sea level rise; loss of species whose temperature tolerance ranges are exceeded (this could be especially problematic for corals); elevated nutrient and sediment loading due to Tundra run-off; saltwater intrusion into freshwater ecosystems such as freshwater marshes and forested wetlands; invasion of warmer water species into areas occupied by cooler habitat species; and physical changes in the Arctic Seas that could have much broader implications by altering flows, food chains, and climate (USDC 1997). The severity of impact on natural resources, including certain essential fish habitat will be determined by natural and human obstruction to inland habitat shifts, resilience of species and populations to withstand changes in environmental conditions, and the rate of environmental change (USDC 1997a).

See table of contents for the following table:

Table 9.1 Summary of non-fishing adverse impacts to essential fish habitat.

9.1.3 Habitat Conservation and Enhancement Recommendations

Habitat alteration may lower both the quantity and quality of species production through physical changes or chemical contamination of habitat. Species and individuals within species differ in their tolerance to effects of habitat alteration. It is possible for the timing of a major alteration event and the occurrence of a large concentration of living marine resources to coincide in a manner that may affect fishery stocks and their supporting habitats. The effects of such events may be masked by natural phenomena or may be delayed in becoming evident. However, the process of habitat degradation more characteristically begins with small-scale projects that result in only minor losses or temporary disruptions to organisms and habitat. As the number and rate of occurrence of these and other major projects increases, their cumulative and synergistic effects become apparent over larger areas. It is often difficult to separate the effects of habitat alteration from other factors such as fishing mortality, predation, and natural environmental fluctuations. Decreasing the probability of impact will lead to the highest protection of EFH. The probability of impact directly relates to the amount human activity we introduce to an environment. The following recommendations are offered to protect EFH.

Near Shore Habitat and Waters (0-3nm)

Recommendation	Area	Species
Minimize construction of structures such as causeways or breaches that would affect local flushing, water temperatures, water quality, lateral drift, and/or migration.	Sensitive areas, special aquatic and vegetation areas	groundfish, salmon, scallop, crab
Minimize construction of structures such as docks that ground on tidal lands during low water events.	Sensitive areas, special aquatic and vegetation areas	groundfish, salmon, crab
Minimize deposition of fill in tidelands.	Sensitive areas, special aquatic and vegetation areas	groundfish, salmon, crab
Stage rapid response equipment and establish measures for accidental impacts such as oil and hazardous material spills.	ports, sensitive areas	groundfish, salmon, scallop, crab
Monitor point source pollution sites such as fish processing waste, sewage, and storm water run off outfalls.	ports, vessel processors, communities	groundfish, salmon, scallop, crab
Minimize disposal or dumping of dredge spoils, drilling muds, and municipal and industrial wastes.	known concentration of bottom species and their habitats	groundfish, salmon, scallop, crab
Test dredge spoils prior to marine disposal	port and upland sources	groundfish, salmon, scallop, crab
Establish monitoring that incorporates Federal and State regulatory agency determinations, i.e., tracking database and GIS system	area wide	groundfish, salmon, scallop, crab

Pelagic Habitat and Waters (3-12nm)

Recommendation	Area	Species
Assess cumulative oil and gas production activities.	BSAI, Chukchi Sea, OCS, Cook Inlet, GOA	groundfish, salmon, scallop, crab
Identify marine disposal sites.	area wide	groundfish, salmon, scallop, crab
Establish monitoring that incorporates Federal and State regulatory agency determinations, i.e., tracking database and GIS system	area wide	groundfish, salmon, scallop, crab
Establish no discharge zones for ballast waters to prevent introduction of non-indigenous species and chemical contaminants.	ports, known gyres areas	groundfish, salmon, scallop, crab
Minimize disposal or dumping of dredge spoils, drilling muds, and municipal and industrial wastes.	known concentration of bottom species and their habitats	groundfish, salmon, scallop, crab

Offshore Habitat and Waters (>12 nm)

Recommendation	Area	Species
Establish monitoring that incorporates Federal and State regulatory agency determinations, i.e., tracking database and GIS system	area wide	groundfish, salmon, scallop, crab
Establish no discharge zones for ballast waters to prevent introduction of non-indigenous species and chemical contaminants.	known offshore gyre areas	groundfish, salmon, scallop, crab
Minimize disposal or dumping of dredge spoils, drilling muds, and municipal and industrial wastes.	known concentration of bottom species and their habitats	groundfish, salmon, scallop, crab

9.1.4 References

Baker, J.E., T.M. Church, S.J. Eisenreich, W.F. Fitzgerald, and J.R. Scudlark. 1993. Relative atmospheric loadings of toxic contaminants and nitrogen to great waters. Report to U.S. Environmental Protection Agency Great Waters Program Coordinator. 142p

Berg, R. J. 1977. An updated assessment of biological resources and their commercial importance in the St. George Basin of the eastern Bering Sea. OCSEAP Research Unit #437, NMFS, Juneau, Alaska, 116p.

Bisson, P.A., and R.E. Bilby. 1982. Avoidance of suspended sediment by juvenile coho salmon. North American Journal of Fisheries Management 2:371-374.

Bisson, P.A., and R.E. Bilby, M.D. Bryant, C.A. Dolloff, G.B. Grette, R.A. House, M.L. Murphy, K.V. Koski, and J.R. Sedell. 1987. Large woody debris in forested streams in the Pacific Northwest: past, present, and future. IN: Streamside Management: Forestry and Fishery Interactions. Edited by Ernest O. Salo and Terrance W. Cundy. College of Forest Resources, University of Washington, Seattle, Washington. University of Washington, Institute of Forest Resources. Contribution No. 57.

Brown, G.W. and J.T. Krygier. 1970. Effects of clearcutting on stream temperature. Water Resour. Res. 6(4):1133-1139.

Bue, B. G., S. Sharr, and J. E. Seeb. In press. Evidence of damage to pink salmon populations inhabiting Prince William Sound, Alaska, two generations after the *Exxon Valdez* oil spill. Transactions of the American Fisheries Society.

Carins, J. 1980. Coping with point source discharges. Fisheries 5(6):3.

Carpenter, E.J., S.J. Anderson, G.R. Harvey, H.P. Milkas, and B.B. Peck. 1972. Polystyrene spherules in coastal waters. Science 178: 749-750.

Carlton, J.T. 1985. Transoceanic and interoceanic dispersal of coastal marine organisms: the biology of ballast water. Oceanography and Marine Biology, An Annual Review 23: 313-371.

Cederholm, C.J. and L.M. Reid. 1987. Impact of Forest Management on Coho Salmon (Oncorhynchus kisutch) Populations of the Clearwater Rivers, Washington: A Project Summary. IN: Streamside Management: Forestry and Fishery Interactions. Edited by Ernest O. Salo and Terrance W. Cundy. College of Forest Resources, University of Washington, Seattle, Washington. University of Washington, Institute of Forest Resources. Contribution No. 57.

Cederholm, C.J. and L.M. Reid and E.O. Salo. 1981. Cumulative effects of logging road sediment of salmonid populations in the Clearwater River, Jefferson County, Washington. Pages 38-74 in Proc. from the conference: Salmon - Spawning Gravel: a renewable resource in the Pacific Northwest. Rep. No. 39. Water Research Center, Pullman, Wash.

Culp, J.M. and R.W. Davies. 1983. An assessment of the effects of streambank clear cutting on macroinvertebrate communities in a managed watershed. Canadian Technical Report of Fisheries and Aquatic Sciences No. 1208. 116p.

Deis, J. 1984. Bering Sea summary report, outer continental shelf oil and gas activities in the Bering Sea and their onshore impacts. U.S. Dept. of the Interior, Minerals Management Service, OCS Infor. Rept. MMS 84-0076, prepared by Rogers, Golden and Halpern, Inc., Reston, Virginia, 75p.

Faris, Tamra L. 1988. USDC, NOAA, National Marine Fisheries Service. Environmental effects of finfish cage culture. Fourth Alaska Aquaculture Conference, November 19-21, 1987, Sitka, Alaska. Alaska Sea Grant College Program No. 88-4. pp. 167-172.

Goldsborough, W.J. 1997. Human impacts on SAV – a Chesapeake Bay case study. In: Aquatic Coastal Submerged Aquatic Vegetation. ASMFC Habitat Management Series #1. Washington, D.C.

Gould, E., Greig, R.A., Rusanowsky, D., and B.C. Marks. 1985. Metal-exposed sea scallops, Placopecten magellanicus: A comparison of the effects and uptake of cadmium and copper. In F.J. Thurberg, A. Calabrese, and W.B. Vernberg (Eds), Marine Pollution and Physiology: Recent Advances. Univ. South Carolina Press, Columbia S.C. pp. 157-186.

Gould, E., and B.A. Fowler. 1991. Scallops and Pollution. In: Sandra E. Shumway, (Ed), Scallops: biology, ecology, and aquaculture. Elsevier, N.Y. 1991.

Hartman, G., J.C. Scrivener, L.B. Holtby, and L. Powell. 1987. Some effects of different streamside treatments on physical conditions and fish population processes in Carnation Creek, a Coastal rain forest stream in British Columbia. IN: Streamside Management: Forestry and Fishery Interactions. Edited by E. O. Salo and T. W. Cundy. University of Washington, Institute of Forest Resources. Contribution No. 57.

Heifetz, J., M.L. Murphy, K.V. Koski. 1986. Effects of logging on winter habitat of juvenile salmonids in Alaskan streams. North American Journal of Fisheries Management. 6:52-58.

Heintz, R. A., J. W. Short, and S. D. Rice. Unpublished manuscript. Sensitivity of fish embryos to weathered crude oil: Part II. Incubating downstream from weathered *Exxon Valdez* oil caused increased mortality of pink salmon (*Oncorhynchus gorbuscha*) embryos. Submitted to Environmental Science & Technology.

Klein, D.H., and E.D. Goldberg. 1970. Mercury in the marine environment. Env. Sci. Tech. 4(9):765-768.

LaPerriere, J.D., S.M. Wagener, and D.M. Bjerklie. 1985. Gold mining effects on heavy metals in streams, Circle Quadrangle, Alaska. Water Resources Bulletin 21:245-252.

Larsen, P.F., and R.M. Lee. 1978. Observations on the abundance, distribution, and growth of postlarval sea scallops, Placopecten magellanicus, on Georges Bank. The Nautilus 92:112-115.

Leibovitz, L., Schott, E.F., and R.C. Karney. 1984. Diseases of wild, captive, and cultured scallops. In: J.M. Capuzzo (Ed), Bay scallop fishery: Problems and management. Woods Hole Oceanographic Institution Tech. Rep. 84-38, pp. 8.

Lloyd, D.S., J. P. Koenings, J.D. LaPerriere. 1987. Effects of turbidity in fresh waters of Alaska. North American Journal of

Fisheries Management 7:18-33.
Mauzen, K.P., C.Birkeland and P.K. Dayton. 1968. Feeding behavior of asteroids and escape responses of their prey in the Puget Sound region. Ecology 49:603-619.
Mearns, A.J., and D.R. Young. 1977. Chromium in the marine environment. In: C.S. Giam (Ed), Pollutant effects on marine organisms. Lexington Books: Lexington MA pp. 43-44.
Meehan, W.R., W.A. Farr, D.M. Bishop, and J.H. Patric. 1969. Some effects of clearcutting on salmon habitat of two southeast Alaska streams. Inst. Northern Fore., Pacific Northwest & Range Exp. Sta. USDA Forest Serv. Res. Pap. PNW-82.
Morris, B.F. 1981. An assessment of the living marine resources of the central Bering Sea and potential resource use conflicts between commercial fisheries and petroleum development in the Navarin Basin, proposed sale 83. NOAA Technical Memorandum, NMFS, F/AKR2, Alaska, 232p.
Morris, B.F. 1987. Living marine resources of the Shumagin oil and gas lease sale 86. NOAA Technical Memorandum, NMFS, F/AKR8, 195p.
Myren, R.T. and R.J. Ellis. 1984. Evaportranspiration in forest succession and long-term effects upon fishery resources: a consideration for management of our old-growth forests. Pages 183-186 IN: M.R. Meehan, T.R. Merrill, Jr. and T.A. Hanley, eds. Fish and wildlife relationships in old growth forests. American Institute of Fishery Research Biologists.
National Marine Fisheries Service. 1979. Living marine resources, commercial fisheries and potential impacts of oil and gas development in the St. George Basin, eastern Bering Sea. Northwest and Alaska Fisheries Center, 133p.
National Marine Fisheries Service. 1980. Living marine resources and commercial fisheries relative to potential oil and gas Development in the northern Aleutian shelf area. NWAFC, Auke Bay Laboratory, Alaska Region, Juneau, Alaska, Juneau, Alaska, 92p.
Nelson, C.H., D.E. Pierce, K.W. Leong, and F.F. H. Wang, 1975. Mercury distribution in ancient and modern sediment of northeastern Bering Sea. Marine Geology 18:91-104.
Nelson,C.H. and K.R. Johnson. 1987. Whales and walruses as tillers of the sea floor. Scientific American, February 1997. pp 112 - 117.
North Carolina Department of Environment, Health, and Natural Resources. 1990. North Carolina coastal marinas -- water quality assessment. Division of Environmental Management. Report 90-01. 74 p.
P.F.M.C. 1987. DRAFT Eight amendment to the fishery management plan for commercial and recreational salmon fisheries off the coasts of Washington, Oregon, ad California commencing in 1987. Pacific Fishery Management Council.
Palmisano,J.F. and J.A. Estes. 1977. Ecolgical interactions involving the sea otter. In: The environment of Amchitka Island, Alaska. Ed: Merritt, M.L. and R.G. Fuller. Technical Information Center, Energy Research and Development Association. pp 527-568.
Pesch, G.G., Stewart, N.E., and C. Pesch. 1979. Copper toxicity to the bay scallop (Argopecten irradians). Bull. Environ. Contam. Toxicol. 23(6):765-769.
Phillips, M.J., M.C.M. Beveridge and J.F. Muir. 1985. Waste output and environmental effects of rainbow trout cage culture. International Council for the Exploration of the Sea, C.M. F: 21/Mariculture Committee/Theme Session W.
Rice, S.D., Moles, A., Taylor, T.L., and J.F. Karinen. 1979. Sensitivity of 39 Alaskan marine species to Cook Inlet crude oil and No. 2 fuel oil. In: Proceedings, Oil Spill Conference 19 Mar 1979, Los Angeles, CA (pp. 549-554). NOAA/NMFS Auke Bay Lab.
Rice, S.D., D.A. Moles, J.F. Karinen, S. Korn, M.G. Carls, C.C. Brodersen, J.A. Gharrett, and M.M. Babcock. 1984. Effects of petroleum hydrocarbons on Alaskan aquatic organisms: a comprehensive review of all oil-effects research on Alaskan fish and invertebrates conducted by the Auke Bay Laboratory, 1970-1981. NOAA Tech. Mem., NMFS F/NWC-67, Seattle, Washington, 128p.
Sease, J.L. and D.G. Chapman. 1988. IN: Selected marine mammals of Alaska: species accounts with research and management recommendations. Lenifer, Jack W., Ed. Marine Mammal Commission, Washington, D.C. pp 17-38.
Scott, G.I., M.H. Fulton, J.Kucklick, T. Siewicki, T. Shearer, F. Holland, T. Chandler and D. Porter. 1997. Chemical Contaminants in the South Atlantic Bight: A Myriad of Contaminants-Which Ones Count? In: G.S. Kleppel and M. R. DeVoe (Eds.). The South Atlantic Bight land use - coastal ecosystem study (LU-CES) Report of a planning workshop. Univ. GA Sea Grant Program and S.C. Sea Grant Program. pp 36-37.
Scott, G.I. 1997. Assessment of risk reduction strategies for the management of agricultural nonpoint source runoff in estuarine ecosystems of the southeastern United States. Unpublished report of the National Marine Fisheries Service, Charleston Laboratory.
Sedell, J.R. and F.J. Swanson. 1984. Ecological characteristics of streams in old-growth forests of the Pacific Northwest, Pages 9-16 IN: M.R. Meehan, T.R. Merrill, Jr. and Ta. Hanley, eds. Fish and wildlife relationships in old-growth forests. American Institute of Fishery Research Biologists.
Shumway, S.E. 1990. A review of the effects of algal blooms on shellfish and aquaculture. Journal World Aquaculture Society.
Sindermann, C.J. 1979. Environmental stress in oceanic bivalve mollusc populations. Proc. Nat. Shellfisheries Assoc. 69:147-156.
Spies, R. B., S. D. Rice, D. A. Wolfe, and B. A. Wright. 1996. The effects of the Exxon Valdez oil spill on the Alaskan coastal environment. American Fisheries Society Symposium 18:1-16.
Stolpe, N. 1997. New Jersey Fishnet. November 2. 1997.
Swanston, D.N. 1974. The forest ecosystem of southeast Alaska. Soil mass movement. General Technical Report PNW-17. U.S. Department of Agriculture. Forest Service. Pacific Northwest Forest and Range experiment Station. Portland,

Oregon.
Thorsteinson, F.V., and L.K. Thorsteinson. 1982. Finfish resources. In Proceedings of a synthesis meeting: the St. George Basin environment and possible consequences of planned offshore oil and gas development, OCSEAP, U.S. Departments of Commerce and Interior, Juneau, Alaska, pp 11-139.
University of Aberdeen. 1978. A physical and economic evaluation of loss of access to fishing grounds due to oil and gas installations in the North Sea, Aberdeen, 152p.
U.S. Department of Commerce (USDOC). 1978. Commercial Tanner crab fishery off the Coast of Alaska, fishery management plan and proposed regulations, Federal Register Vol. 43 No. 95, 21170-21251.
U.S. Department of Commerce (USDC). 1997. General description of non-fishing threats to essential fish habitat in the mid-Atlantic region (draft). NOAA/NMFS Unpublished document 20 p.
U.S. Environmental Protection Agency (USEPA). 1993. Guidance for specifying management measures for sources of nonpoint pollution in coastal waters. Office of Water. 840-B-92-002. 500+ p.
Vattuone, G.M., Griggs, K.S. McIntire, D.R. Littlepage, J.L. and F.L. Harrison. 1976. Cadmium concentrations in rock scallops in comparison with some other species. Lawrence Livermore National Laboratory, UCRL-52022. 31 pp.
Wassman, R., and J. Ramus. 1973. Seaweed invasion. Natural History 82(10): 25-36.
Weber, D.D., 1965. Growth of immature king crab Paralithodes camtschatica (Tilesius). University of Washington, Masters Thesis, 100p
Wood, J.M. 1974. Biological cycles for toxic elements in the environment. In Science, No. 4129, Vol. 183, 1049-1052.
Zheng, J. and G.H. Kruse (MS). ICES International Symposium on Recruitment Dynamics of Exploited Marine Populations: Physical-Biological Interactions. September 22-24, 1997, Baltimore, Maryland.

9.2 Identification of Fishing Activities Affecting EFH

Adverse effects from fishing activities may include physical, chemical, or biological alterations of the substrate, and loss of, or injury to, benthic organisms, prey species and their habitat, and other components of the ecosystem. FMPs must include management measures that minimize adverse effects on EFH from fishing, to the extent practicable, and identify conservation and enhancement measures. The FMP must contain an assessment of the potential adverse effects of all fishing activities used in waters described as EFH. This assessment should consider the relative impacts, compared to natural impacts and cycles, of all fishing equipment types used in EFH on different types of habitat found within EFH. Special consideration should be given to equipment types that will affect habitat areas of particular concern. In completing this assessment, Councils should use the best scientific information available, as well as other appropriate information sources, as available. Included in this assessment should be consideration of the establishment of research closure areas and other measures to evaluate the impact of any fishing activity that physically alters EFH.

Councils must act to prevent, mitigate, or minimize any adverse effects from fishing, to the extent practicable, if there is evidence that a fishing practice is having an identifiable adverse effect on EFH. In determining whether it is practicable to minimize an adverse effect from fishing, Councils should consider whether, and to what extent, the fishing activity is adversely impacting EFH, including the fishery; the nature and extent of the adverse effect on EFH; and whether the management measures are practicable, taking into consideration the long and short-term costs as well as benefits to the fishery and its EFH, along with other appropriate factors, consistent with national standard 7.

Fishery management options may include, but are not limited to:

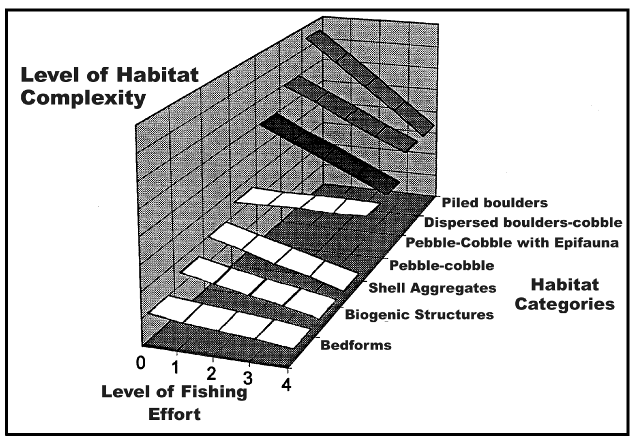
> <u>Fishing equipment restrictions</u>. These options may include, but are not limited to: Seasonal and areal restrictions on the use of specified equipment; equipment modifications to allow escapement of particular species or particular life stages (e.g., juveniles); prohibitions on the use of explosives and chemicals; prohibitions on anchoring or setting equipment in sensitive areas; and prohibitions on fishing activities that cause significant physical damage in EFH.
>
> <u>Time/area closures</u>. These actions may include, but are not limited to: Closing areas to all fishing or specific equipment types during spawning, migration, foraging, and nursery activities; and designating zones for use as marine protected areas to limit adverse effects of fishing practices on certain vulnerable or rare areas/species/life history stages, such as those areas designated as habitat areas of particular concern.
>
> <u>Harvest limits</u>. These actions may include, but are not limited to, limits on the take of species that provide structural habitat for other species assemblages or communities, and limits on the take of prey species.

9.2.1 Literature Review on the Effects of Fishing Gear on Habitat

Two literature reviews on the effects of fishing gear on habitat are included in this section. The first is an executive summary of a paper written by Dr. Peter Auster and Dr. Richard Langton called "The Indirect Effects of Fishing". This paper was contracted to the authors by NMFS, through the American Fisheries Society, specifically to address the impact of fishing on EFH. The paper summarizes and interprets the scientific literature on the effects of fishing on structural components of habitat, infaunal and epifaunal communities, and ecosystem processes. Copies of the Auster and Langton (1998) paper are available from the NMFS. The second paper included in this section was written by Ivan Vining, David Witherell, and Jon Heifetz, entitled "The Effects of Fishing Gear on Benthic Communities". Their paper is a literature review of scientific studies on the effects of different gear types. The paper was originally prepared for the NPFMC's 1998 Ecosystems Considerations chapter of the annual stock assessment documents, and is included here in its entirety. Copies are available from the Council office.

9.2.1.1 The Indirect Effects of Fishing: An Executive Summary

A paper entitled "The Indirect Effects of Fishing" was prepared by Peter Auster and Richard Langton under contract from the American Fisheries Society. The paper summarizes and reviews the current literature on fishing impacts as they relate to EFH. A first draft was released for peer review on January 2, 1998 and a final draft released in April, 1998. Interested persons may obtain this paper and other cited documents from the Council office.



Conceptual model of how fishing could differentially affect habitat depending on its complexity.

The paper discusses the studies within four broad subject areas: effects of gear on non-landed target species, effects on structural components of habitat, effects on benthic community structure, and effects on ecosystem level processes. Although a vast majority of the scientific studies on gear impacts have focused on trawl gear, the authors have attempted to analyze the impacts of habitat disturbance, rather than focus on the impacts of each gear type on habitat. Towards that end, the authors have developed a conceptual model to assist managers with understanding how fishing gear could impact different habitats. The adjacent figure illustrates this. In very complex habitats, such as piled boulders or cobble with epifauna (corals, bryozoans, anenemones, etc.), even relatively low levels of fishing effort can drastically alter the habitat. On more simple habitats, such as bedforms (such as sand or silt bottoms), fishing has a relatively minor effect on the habitat complexity. An abstract of the Auster and Langton paper is provided below.

<u>Abstract</u>

The Sustainable Fisheries Act of 1996 mandates that regional fishery management Councils designate essential fish habitat (EFH) for each of the species which are managed, assess the effects of fishing on EFH, and develop conservation measures for EFH where needed. This synthesis of effects of fishing on fish habitat was produced to aid the fishery management councils in assessing the impacts of fishing activities. A wide range of studies were reviewed that reported effects of fishing on habitat (i.e., structural habitat components, community structure, and ecosystem processes) for a diversity of habitats and fishing gear types. Commonalities of all studies included immediate effects on species composition and diversity and a reduction in habitat complexity. Studies of acute effects were found to be a good

predictor of chronic effects. Recovery after fishing was more variable, depending on habitat type, life history strategy of component species, and the natural disturbance regime. The ultimate goal of gear impact studies should not be to retrospectively analyze environmental impacts but ultimately to develop the ability to predict outcomes of particular management regimes. Synthesizing the results of these studies into predictive numerical models is not currently possible. However, conceptual models are presented which coalesce the patterns found over the range of observations. Conceptual models can be used to predict effects of gear impacts within the framework of current ecological theory. Initially, it is useful to consider fishes' use of habitats along a gradient of habitat complexity and environmental variability. A model is presented of gear impacts on a range of seafloor types and is based on changes in the structural habitat values. Disturbance theory provides the framework for predicting effects of habitat change based on spatial patterns of disturbance. Alternative community state models, and type 1-type 2 disturbance patterns, may be used to predict the general outcome of habitat management. Primary data are lacking on the spatial extent of fishing induced disturbance, the effects of specific gear types along a gradient of fishing effort, and the linkages between habitat characteristics and the population dynamics of fishes. Adaptive and precautionary management practices will therefore be required until empirical data becomes available for validating model predictions.

9.2.1.2 The Effects of Fishing Gear on Benthic Communities

Portions of the following section have been excerpted from the following paper:
Vining, I., D. Witherell, and J. Heifetz. 1997. The effects of fishing gear on benthic communities. p.13-25. Ecosystem Considerations for 1998. North Pacific Fishery Management Council, Anchorage, Alaska.

In recent years, there has been a growing awareness and concern about the effects of resource extraction on ecosystems. Fishery managers around the world are beginning to incorporate, or at a minimum acknowledge, the effects of fishing on marine ecosystems. The groundfish fisheries in Alaska are no exception. Concern has been expressed by scientists, conservationists, fishermen, and others about potential negative effects of fishing gear on bottom habitat, particularly with regard to habitat alteration. In this chapter, we provide a review of scientific studies done to date on the effects of fishing gear on benthic communities of the Gulf of Alaska, Bering Sea, and Aleutian Islands areas.

Fisheries in the North Pacific are numerous and utilize different gear types. The fisheries and associated gear for the Bering Sea/Aleutian Islands (BSAI) and Gulf of Alaska fisheries (GOA) are listed in the adjacent table. Federal regulation § 679.2 specifies the following authorized gear types: dive, fixed gear, hook-and-line, jig, longline, longline pot, non-pelagic trawl, pelagic trawl, pot-and-line, scallop dredge, and troll gear. In this section, we summarize potential effects only for primary gears used in the groundfish, scallop, and crab fisheries.

Fishing Gear used in the North Pacific, by fishery.

FMP	Fishery	Gear
BSAI and GOA	groundfish	trawl, longline, jig, pot
BSAI and GOA	halibut	longline, hook&line, troll, jig
BSAI and GOA	scallop	dredge
BSAI	crab	pot
BSAI and GOA (State managed)	salmon	gill net, seine, troll line, fish wheels, or spears
non-FMP (State)	herring	trawl, seine, gill net, pound net
non-FMP (State)	shrimp	pots, trawls
non-FMP (State)	razor clam	shovel, fork
non-FMP (State)	sea urchin	handpicking, aided by diving gear or abalone iron
non-FMP (State)	octopus	pot
non-FMP (State)	abalone	diving gear and abalone iron
non-FMP (State)	sea cucumber	handpicking, aided by diving gear

If the gear, habitat, and communities were homogeneous, studies designed to measure the effect of fishing on benthic communities would be much simpler. However, there is heterogeneity in all aspects of fishing, as well as the habitat and communities affected by fishing gear. When studying gear effect, many questions need to be answered, such as: Do all gears have similar effects? How much actual damage is being done? How long will the damage last? How will damage be measured? Does the extent and longevity of damage depend on bottom type? Does the fishing affect all organisms in the community equally? The purpose of this section of the Ecosystems Chapter is to review the completed work or the work in progress to answer some of these questions, and summarize conclusions. A summary of literature used for this paper is provided in Table 1.

Trawl Gear

Concerns over the effects of trawling are not new, nor limited to the North Pacific. Trawling was an issue, as early as 1350, when it was banned in the United Kingdom to protect fry of fish (de Groot 1984). Since 1938, studies have been conducted on the east coast of Canada and United States, to evaluate possible effects of trawling on the benthic communities (Ketchen 1947; Graham 1955; Messieh et al. 1991). There has also been an extensive investigation in the North Sea by the Netherlands Institute for Sea Research evaluating the effects of beam-trawl fisheries on the bottom fauna (BEON-RAPPORT 8 1990; Bergman and Hup 1992). The effects of trawling are also being studied in New Zealand and Australia, with special attention being paid to hard-bottom trawling (Hutchings 1990; Jones 1992).

There are people who considered the negative effect of trawl gear "common sense" and "intuitive," and have written articles pointing to likely ways the gear is having a negative effect on the environment (Apollonio 1989; McAllister 1991; Russel 1997). The scientific community, in general, also tends to accept that trawling alters the bottom habitat (Auster et al. 1996). The root of the problem and the cause of controversy lies in the definition of "negative effect" and the degree of change in the benthic habitat or communities before the change is "destructive."

The otter trawl is the principle gear used in bottom trawl fisheries in the GOA and BSAI, and advancements in fishing gear and vessel technology have made gear more efficient. These advances mean that heavier nets are dragging over seabeds, and possibly altering the sea-floor more than was observed in earlier studies. Also, larger ships, with greater horsepower and larger, stronger nets are exploring and fishing areas not previously available to the industry (Auster et al. 1996). A further consideration is the domestication of the groundfish industry in the GOA and BS since the Magnuson Act of 1976, which changed the character of trawling in Alaska from large foreign factory vessels to a mixture of a domestic catcher-processors and numerous smaller catcher vessels.

Physical effects of trawling include plowing and scraping the sea-floor, resuspension of sediment, and lowering of habitat complexity. Plowing and scraping effects depend on towing speed, substrate type, strength of tides and currents, and gear configuration (Jones 1992). It has been found that otter doors tend to penetrate the substrate 1 cm - 30 cm; 1 cm on sand and rock substrates, and 30 cm in some mud substrates (Krost et al. 1990; Jones 1992; Brylinsky et al. 1994). Another factor which will cause variation in the depth of the troughs made by the otter doors is the size (weight) of the doors, i.e., the heavier the doors the deeper the trough (Jones 1992). These benthic troughs can last as little as a few hours or days in mud and sand sediments, over which there is strong tide or current action (Caddy 1973; Jones 1992), or they can last much longer, from between a few months to over 5 years, in seabeds with a mud or sandy-mud substrate at depths greater than 100 m, with weak or no current flow (Krost et al. 1990; Jones 1992; Brylinsky et al. 1994).

Another aspect of plowing and scraping is the alteration done by the footrope. Once again, different types of footropes will cause more or less alteration. Those footropes which are designed to roll over the sea-floor (the type generally on soft bottoms, employed in the GOA and BS), cause little physical alteration, other than smoothing the substrate and minor compression (Brylinsky et al. 1994; Kaiser and Spencer 1996). However, since a trawler may re-trawl the same area several times, these minor compressions can cause a "packing" of the substrate (Schwinghammer et al. 1996). Further compression of the substrate can occur as the net becomes full and is dragged along the bottom.

The trawling of an area can cause resuspension of both inorganic and organic sediments. Churchill (1989) found that trawling can be a significant contributor to the time-averaged suspended sediment load over heavily trawled areas, especially at depths where bottom stress due to tidal and current action is generally weak. In the GOA, there is relatively weak current and tidal action near the sea-floor over much of the groundfish fishing grounds, with a variety of seabed types such as gravely-sand, silty-mud, and muddy to sandy gravel, as well as areas of hard-rock (Hampton et al. 1986). The BS has relatively weak currents, on the other hand, with relatively strong tidal action (currents) accounting for up to 95% of all flow as deep as 200 m, with principally gravely-sand and silty-sand seabed (National Research Council 1996).

The reduction in habitat complexity can be examined in two broad categories: (1) small localized changes, and (2) larger area changes. The small localized changes refer to the smoothing of patchy biogenic depressions and movement of boulders (Auster et al. 1996). The broader area changes refer to the general reductions in habitat complexity with increases in trawling activity (Auster et al. 1996; Schwinghammer et al. 1996).

Mortality can be incurred to those organisms incidentally captured (bycatch), and discarded back into the sea. The mortality rate of the bycatch depends on the species, age and size of a species, the type of gear, the time and type of shipboard handling, and the size of the haul, along with ocean and atmospheric conditions (Hill and Wassenberg 1990; Stevens 1990; Fonds 1991). It is difficult to generalize the fate of bycaught benthic organisms returned to the sea or compare results from different studies on this subject. In addition, studies have only focused on the survival of fish and crab discards.

Several studies have examined the mortality of crabs taken as bycatch in North Pacific trawl fisheries. In one study, a standard sole trawl (with roller gear) in a subarctic area (Bering Sea) caught king and Tanner crabs while fishing for sole, sorted the catch with the time on deck being between .5-1.5 hours, then placed the crabs in holding tanks for 48 hours; the resulting mortality rate was 79% for king crab and 78% for Tanner crab (Stevens, 1990). Blackburn and Schmidt (1988) made observations on instantaneous mortality of crab taken by domestic trawl fisheries in the Kodiak area. They found mortality for soft-shell red king crab averaged 21%, hard-shelled red king crab 1.2%, and 12.6% for Tanner crab. Another trawl study indicated that trawl induced instantaneous mortalities aboard ship were 12% for Tanner crab and 19% for red king crab (Owen 1988). Fukuhara and Worlund (1973) observed an overall Tanner crab mortality of 60-70% in the foreign Bering Sea trawl fisheries. They also noted that mortality was higher in the summer (95%) than in the spring (50%). Hayes (1973) found that mortality of Tanner crab captured by trawl gear was due to time out of water, with 50% mortality after 12 hours. Natural Resource Consultants (1988) reported that overall survival of red king crab and Tanner crab bycaught and held in circulation tanks for 24-48 hours was <22%. In analyses of groundfish plan amendments, the estimated mortality rate of trawl bycaught red king crab and Tanner crab was assumed to be 80% (NPFMC 1993).

Damage or mortality of benthic organisms can occur due to the passage of the trawl over the seabed without actually catching the organisms. Non-retained organisms may be subject to mortality from contact with trawl doors, bridles, footrope, or trawl mesh, as well as exposure to silt clouds produced by trawl gear. Mortality of fish escaping from trawl codends may range from none to 100%, and may depend on numerous factors, including fish species, tow size and duration, the size and type of mesh used (Sangster 1992). Mortality can occur due to contusions, a build-up of lactic acid, scale loss and mucus removal, and skin damage due to abrasion and collision with net walls (Sangster 1992; Chopin and Arimoto 1995).

Studies of fish escapement mortality have exhibited a wide range of results. Very low escapement mortality was observed for Alaskan pollock under experimental conditions (Efanov and Istomin 1988). Main and Sangster (1988) observed that mortality of haddock passing through a diamond mesh codend exhibited delayed mortality: 33% mortality after 11 days and 82% mortality after 108 days. DeAlteris and Reifsteck (1993) observed escapement mortality of scup (Stenotomus chrysops) to be 0% to 50%, and less than 4% for winter flounder (Plueronectes americanus) tested by an experimental codend. Bergman et al. (1989) studied the mortality of fishes escaping from commercial beam trawls, and observed mortalities of dab (Limanda limanda), plaice, and sole totaled 44%, 15%, and 0%, respectively, after being held in a cage for 24 hours. Van Beek et al. (1989) also studied the mortality of sole escaping from beam trawls, and their results indicated that 40% of the sole died after escaping through the meshes. Mortality of herring (Clupea harengus) escaping from trawl codends can be higher than for groundfish. Suuronen et al. (1992) observed mortality of codend escapees to be very high (85-90%), with most deaths occurring 3-8 days after escape. Another study of herring showed lower mortality (3-30%) for herring escaping from codends (Efanov 1981).

Besides direct mortality from being caught and handled, there will be further mortality due to relocation into unsuitable habitat and predation while returning to the sea floor. This type of mortality will also depend on many conditions such as depth, type of species, age and size of species, predator concentration and oceanic conditions. Although there are few studies which have considered these sources of mortality, neither relocation nor predation will likely result in 100% mortality (Hill and Wassenberg, 1990).

Similar to the mortality of bycatch, the survival of benthic organisms in the path of the trawl will depend on several factors. The mortality rate will depend on the species, species age and size, the type of gear, the size of the haul, substrate morphology, and ocean conditions. The most severe damage done to benthic organisms by otter trawls is from the trawl doors, especially sedentary organisms that live in the upper 5 cm of the seabed (Rumohr and Krost, 1991). Rumohr and Krost (1991) further found that thin-shelled bivalves such as *Syndosmya alba*, *Mya* sp. and *Macoma calcarea*, as well as starfish sustain heavy damage due to the trawl doors, whereas thick-shelled bivalves such as *Astarte borealis* and *Corbula gibba* were less likely to be damaged. In one another experiment, hard-shelled red king crab were tethered in the path of an Aleutian combination trawl (Donaldson 1990). Only 2.6% of the crabs that were interacted with the trawl, but not retained, were injured, suggesting a low mortality rate. Other organisms found to be affected by the passage of trawls and specifically the trawl doors are diatoms, nematodes and polychaetes (Brylinsky et al. 1994).

The immediate effect of trawling on hard-bottom seabeds can be intense in certain vulnerable habitats. It was found that from a single tow using roller gear, 3.9% of the octocorals and 30.4% of the stony coral were damaged, as well as 31.7% of the sponges (van Dolah et al., 1987). A similar study in Florida found that 80% of the stony coral and 38% of the soft corals were damaged, as well as 50% of the sponges. However, the trawls in this study were a ridged roller gear assemblage (Tilmant 1979). Both of these studies were in sub-tropical areas. No studies were found assessing trawling in temperate or subarctic hard-bottom habitat, however current work on this is being carried out in the GOA (Heifetz 1997).

Although mortality from bycatch or trawl passage appears to be fairly high for various organisms, some studies have found recolonization can occur over a relatively short time period. Nematodes and polychaetes returned to their pre-trawled levels in less than 7 weeks and diatoms increased in abundance in trawl troughs within 80 days (Brylinsky et al., 1994). Small epibenthic species that have been resuspended can recover to pre-trawl densities in 24 hours (Rumohr and Krost, 1991). The sponges and most of the corals damaged in the hard-bottom studies, returned to their pre-study levels in approximately a year.

One of the principle concerns associated with trawling is the potential effects on benthic organisms that fish depend on for food. At least in the short term, prey items immediately available to fish do not appear to be reduced. Caddy (1973) found that fish and crabs were attracted to the trawl path, presumably to feed on exposed or dead benthos, within 1 hour after fishing. Other studies have also observed increases in scavenging in the wake of beam-trawls (Kaiser and Spencer 1994; Kaiser and Spencer 1996a). Furthermore, the densities of some of the species examined in the study, were 30 times greater than outside the trawl tracks. In Kiel Bay (Baltic Sea), it was believed that cod fed extensively on Arctica islandica which were crushed or broken by trawl doors (Rumohr and Krost 1991; Jones 1992).

Minor short-term changes in individual species distribution are not likely to greatly affect the entire ecosystem, excessively. The ecosystem is in a constant flux, with many natural phenomena making changes to the environment (de Groot 1984; Brylinsky et al. 1994). The specific question is whether fishing causes long-term changes (negative) in the benthic community structure.

There have been changes to benthic communities from trawling due to habitat alteration. The trawl doors may be the most damaging to benthic organisms on a short-term basis. However, even in deep areas where the troughs may be recognized after long periods (5 years), the doors do not likely have an excessive long- term effect on the overall area, because the relatively small trough is between 0.2 - 2 m (Krost et al. 1990; Rumohr and Krost 1991; Brylinsky et al. 1994). The greater long-term damage to the habitat may be caused by the net and footrope due to their much larger width at 3-166 m (1.5-90 fathoms), with many between 20-50 m (Grahm 1955).[3] The smoothing caused by multiple trawls (as discussed earlier) removes patchy biogenic depressions and moves boulders, both of which are extremely important habitat to juvenile fish and crustaceans (Armstrong et al. 1993; Auster et al. 1996). Multiple trawls in an area also pack down and lower the complexity of the substrate which will likely reduce the exchange capacity and lead to less species diversity (Jones 1992; Kaiser and Spencer 1996b; Schwinghamer et al. 1996). Some studies have concluded that trawling tends to favor fast-growing, fast-reproducing and relatively short-lived (r-selected) species, such as polychaetes, at the expense of slow-growing, slow-reproducing and relatively long-lived (k-selected) species such as crustaceans (Reise 1982; de Groot 1984; Kaiser and Spencer 1996b).

Sediment resuspension, as discussed above, has an effect on the benthic communities as well. Increased sediment suspension can cause reduction of light levels on the seabed, smother benthos following resettlement, create anaerobic conditions near the seabed, and reintroduce toxins that may have settled out of the water column (Churchill 1989; Jones 1992, Messieh et al. 1991).

Dredge Gear

Dredging for scallops may affect habitat by causing unobserved mortality to scallops and other marine life, mortality of discards, and modification of the benthic community and sediments. Similar to trawling, dredging places fine sediments into suspension, bury gravel below the surface and overturn large rocks that are embedded in the substrate (NEFMC 1982, Caddy 1973). Dredging can also result in dislodgement of buried shell material, burying of gravel under resuspended sand, and overturning of larger rocks with an appreciable roughening of the sediment surface (Caddy 1968). A study of scallop dredging in Scotland showed that dredging caused significant physical disturbance to the sediments, as

[3] Pers. comm., Chris Blackburn, Alaska Groundfish Databank, Kodiak, AK.

indicated by furrows and dislodgement of shell fragments and small stones (Eleftheriou and Robertson 1992). The authors note, however, that these changes in bottom topography did not change sediment disposition, sediment size, organic carbon content, or chlorophyll content. Observations of the Icelandic scallop fishery off Norway indicated that dredging changed the bottom substrate from shell-sand to clay with large stones within a 3-year period (Aschan 1991). For some scallop species, it has been demonstrated that dredges may adversely affect substrate required for settlement of young to the bottom (Fonseca et al. 1984; Orensanz 1986). Mayer et al. (1991), investigating the effects of a New Bedford scallop dredge on sedimentology at a site in coastal Maine, found that vertical redistribution of bottom sediments had greater implications than the horizontal translocation associated with scraping and plowing the bottom. The scallop dredge tended to bury surficial metabolizable organic matter below the surface, causing a shift in sediment metabolism away from aerobic respiration that occurred at the sediment-water interface and instead toward subsurface anaerobic respiration by bacteria (Mayer et al. 1991). Dredge marks on the sea floor tend to be short-lived in areas of strong bottom currents, but may persist in low energy environments (Messieh et al. 1991).

Two studies have indicated that intensive scallop dredging may have some direct effects on the benthic community. Eleftheriou and Robertson (1992), conducted an experimental scallop dredging in a small sandy bay in Scotland to assess the effects of scallop dredging on the benthic fauna. They concluded that while dredging on sandy bottom has a limited effect on the physical environment and the smaller infauna, large numbers of the larger infauna (mollusks) and some epifaunal organisms (echinoderms and crustaceans) were killed or damaged after only a few hauls of the dredge. Long-term and cumulative effects were not examined, however. Achan (1991) examined the effects of dredging for islandic scallops on macrobenthos off Norway. Achan found that the faunal biomass declined over a four-year period of heavy dredging. Several species, including urchins, shrimp, seastars, and polychaetes showed an increase in abundance over the time period. In summary, scallop gear like other gear used to harvest living aquatic resources, may effect the benthic community and physical environment relative to the intensity of the fishery.

Several studies have addressed mortality of scallops not captured by dredges. In Australia, this type of fishing gear typically harvests only 5-35% of the scallops in their path, depending on dredge design, target species, bottom type, and other factors (McLoughlin et al. 1991). Of those that come in contact with the dredge but are not captured, some elude the passing dredge and recover completely from the gear interaction. Some injuries may occur during on board handling of undersized scallops that are returned to the sea or during gear interactions on the sea floor (Caddy 1968; Naidu 1988; Caddy 1989), and delayed mortality can result from siltation of body cavities (Naidu 1988) or an increased vulnerability to disease (McLoughlin et al. 1991) and predation (Elner and Jamieson 1979). Caddy (1973) estimated incidental dredge mortality to be 13 to 17%, based on observations of broken and mutilated shells of Atlantic sea scallops. However, a submersible study of sea scallops from the mid-Atlantic indicated that scallop dredges capture with high efficiency those scallops which are within the path of the scallop dredge and cause very low mortality among those scallops that are not captured (NEFMC 1988). Murawski and Serchuk (1989) made submersible observations of dredge tracks and found a much lower mortality rate (<5%) for Atlantic sea scallops. The difference in mortality between these two studies can be attributed to the substrate on which the experiments were conducted. Caddy's work was done in a sandy/gravelly area and Murawski and Serchuk worked on a smooth sand bottom. Shepard and Auster (1991) investigated the effect of different substrate types on dredge induced damage to scallops and found a significantly higher incidental damage on rock than sand, 25.5% versus 7.7%. For weathervane scallops, mortality is likely to be lower as this species prefers smoother bottom substrates consisting of mud, clay, sand, or gravel (Hennick 1970a, 1973).

Atlantic sea scallop beds and the benthic community associated with scallop fishing grounds in the Bay of Fundy were assessed in 1969 (Caddy 1976). During the intervening years, the area has seen great changes in fishing pressure with recent effort amounting to more than 90 vessels of over 25 GRT continuously fishing the grounds with Digby drags for days at a time (Kenchington and Lundy 1991). Since 1969, there have also been dramatic fluctuations in scallop abundance, including both record highs and lows for this century. In particular, scallop abundance rose to over 1000 times "normal" levels with the recruitment of two strong year-classes in 1985 and 1986. This information indicates that extensive dredging does not affect the recruitment of scallops to a productive ground.

Observations from scallop fisheries across the state suggest that mortality of crab bycatch may be lower on average than those taken in trawl fisheries, perhaps due to shorter tow times, shorter exposure times, and lower catch weight and volume. For crab taken as bycatch in the Gulf of Alaska weathervane scallop fishery, Hennick (1973) estimated that about 30% of Tanner crabs and 42% of the red king crabs bycaught in scallop dredges were killed or injured. Hammerstrom and Merrit (1985) estimated mortality of Tanner crab at 8% in Cook Inlet. Kaiser (1986) estimated mortality rates of 19% for Tanner crab and 48% for red king crab bycaught off Kodiak Island. Urban et al. (1994) recorded that in 1992, 13-35% of the Tanner crab bycaught were dead or moribund before being discarded with the highest mortality rate occurring on small (<40 mm carapace width, CW) and large (>120 mm CW) crabs. Delayed mortality of Tanner crab resulting from injury or stress has not estimated. Mortality in the Bering Sea appears to be lower than in the Gulf of Alaska, in part due to different sizes of crab taken. Observations from the 1993 Bering Sea scallop fishery indicated lower bycatch mortality of red king crab (10%), Tanner crab (11%) and snow crab (19%) (Barnhart et al. 1996). As with observations from the Gulf of Alaska, mortality appeared to be related to size, with larger and smaller crabs having higher mortality rates on average than mid-sized crabs (Barnhart et al. 1996). Delayed mortality was not estimated. In one groundfish plan amendment analysis, all sources of crab mortality were examined; in this analysis a 40% discard mortality rate for all crab species was assumed for scallop fisheries (NPFMC 1993).

Adverse effects of scallop dredges on benthic communities in Alaska may be lower in intensity than trawl gear. Studies on effects of trawl and dredge gear have revealed that, in general, the heavier the gear in contact with the seabed, the greater the damage (Jones 1992). Scallop dredges generally weigh less than most trawl doors, and the relative width they occupy is significantly smaller. A 15' wide New Bedford style scallop dredge weighs about 1,900 lbs (Kodiak Fish Co. data). Because scallop vessels generally fish two dredges, the total weight of the gear is 3,800 lbs. Trawl gear can be significantly heavier. An 850 HP vessel pulling a trawl with a 150' sweep may require a pair of doors that weigh about 4,500 pounds. Total weight of all trawl gear, including net, footrope, and mud gear would weigh even more.[4] Hence, based on weight of gear alone, scallop fishing may have less effect than bottom trawling, however its effects may be more concentrated.

Longline Gear

Very little information exists regarding the effects of longlining on benthic habitat. Observations of halibut longline gear made by NMFS scientists during submersible dives off southeast Alaska provide some information (NPFMC 1992). The following is a summary of these observations: "Setline gear often lies slack on the sea-floor and meanders considerably along the bottom. During the retrieval process, the line sweeps the bottom for considerable distances before lifting off the bottom. It snags on whatever objects are in its path, including rocks and corals. Smaller rocks are upended, hard corals are broken, and soft corals appear unaffected by the passing line. Invertebrates and other light weight

[4] Pers. comm., Teresa Kandianis, 2977 Fox Road, Ferndale, WA 98248.

objects are dislodged and pass over or under the line. Fish, notably halibut, frequently moved the groundline numerous feet along the bottom and up into the water column during escape runs disturbing objects in their path. This line motion was noted for distances of 50 feet or more on either side of the hooked fish."

Some crabs are caught incidentally by longline gear in pursuit of groundfish, and a portion of these crabs die. No field or laboratory studies have been made to estimate mortality of crab discarded in longline fisheries. However, based on condition factor information from the trawl survey, mortality of crab bycatch has been estimated and used in previous analyses (NPFMC 1993). Discard mortality rates were estimated at 37% for red king crab and 45% for *C. bairdi* Tanner crab taken in longline fisheries. No observations had been made for snow crab, but mortality rates may be similar to Tanner crab.

Mortality of groundfish discarded in longline fisheries has not been studied extensively in Alaska. Studies with Pacific halibut have shown that discards may have high mortality if not released carefully from hooks. Additionally, some species such as rockfish may not survive changes in pressure when they are hauled up quickly from the bottom. Mortality of discarded halibut has been estimated to be about 15% for most longline fisheries (Williams 1997).

Pot Gear

Pot gear is used in the North Pacific to harvest crabs and groundfish. This gear type likely affects habitat during the process of setting and retrieving pots; however, no research has been conducted to date.

Like other fisheries, pot fisheries incur some bycatch of incidental fish and crab. The groundfish pot fishery targets Pacific cod, but takes other species such as crab and flatfish which are discarded. Mortality of bycaught fish in groundfish pot fisheries has not been studied, with the exception of Pacific halibut. Based on viability data, it has been estimated that mortality of halibut bycaught in groundfish pot fisheries averages about 7% (Williams 1997). Bycatch in crab pot fisheries includes crabs, octopus, Pacific cod, halibut, and other flatfish (Tracy 1994). Crab bycatch includes females of target species, sublegal males of target species, and non-target crab.

There are a variety of effects caused by handling, ranging from sublethal (reduced growth rates, molting probabilities, visual acuity from bright lights, and vigor) to lethal effects. Several laboratory and field studies have been conducted to determine mortality caused by handling juvenile and female crab taken in crab fisheries. Studies have shown a range of mortality due to handling based on gear type, species, molting stage, number of times handled, temperature, and exposure time (Murphy and Kruse 1995). Handling mortality may have contributed to the high natural mortality levels observed for Bristol Bay red king crab in the early 1980s (65% for males and 82% for females) that, along with high harvest rates, resulted in stock collapse (Zheng et al. 1995). However, another study concluded that handling mortality was not responsible for the decline on the red king crab fishery (Zhou and Shirley 1995a). Byersdorfer and Watson (1992, 1993) examined red king crab and Tanner crab taken as bycatch during the 1991 and 1992 red king crab test fisheries. Instantaneous handling mortality of red king crab was <1% in 1991, and 11.2% in 1992. Stevens and MacIntosh (1993) found average overall mortality of 5.2% for red king crabs and 11% for Tanner crabs on one commercial crab vessel. Authors recommend these results be viewed with caution, noting that experimental conditions were marginal. Mortality for red king crab held 48 hours was 8% (Stevens and MacIntosh 1993, as cited in Queirolo et al. 1995). A laboratory study that examined the effects of multiple handling indicated that mortality of discarded red king crabs was negligible (2%), although body damage increased with handling mortality (Zhou and Shirley 1995a). Delayed mortality of crabs due to handling does not appear to be influenced by method of release. In an experiment done during a test fishery, red king crab thrown off the deck while the vessel was moving versus those gently placed back into the ocean showed no differences in tag return rates (Watson and Pengilly 1994). Handling methods on mortality has been shown to be non-significant in laboratory experiments with red king crab (Zhou and Shirley 1995a, 1995b) and Tanner crab (MacIntosh et al. 1995). Although handling did not cause mortality, injury rates were directly related to the number of times handled.

Mortality of crabs is also related to time out of water and air temperature. A study of red king and Tanner crabs found that crabs exposed to air exhibited reduced vigor and righting times, feeding rates (Tanner crabs), and growth (red king crabs) (Carls and Clair 1989). Cold air resulted in leg loss or immediate mortality for Tanner crabs, whereas red king crabs exhibited delayed mortality that occurred during molting. A relationship was developed to predict mortality as the product of temperature and duration of exposure (measured as degree hours). Because BSAI crab fisheries occur during November through February, cold exposure could cause significant handling mortality to crabs not immediately returned to the ocean. However, Zhou and Shirley (1995) observed that average time on deck was generally 2 to 3 minutes, and they concluded that handling mortality was not a significant source of mortality.

Salmon Fishing Gear

Directed fisheries on salmon in Alaska include marine commercial and recreational hook-and-line fisheries; marine commercial gill-net and seine fisheries; and estuarine and riverine gill-net (both set-net and drift), recreational, personal use, and subsistence fisheries. Two types of impacts can occur: (1) direct effects of the fishing gear on habitat; and (2) by-catch or entanglement of non-target species. In the marine fisheries, direct impact of the gear on marine habitats is limited, but some localized effects can occur, such as trolling weights damaging coral or purse seines damaging kelp beds or benthic structure. By-catch and entanglement of non-target species can occur in the marine fisheries, such as by-catch of demersal rockfish in hook-and-line fisheries, and entanglement of seabirds and marine mammals in net fisheries. In the estuarine and riverine fisheries, direct impacts on riparian vegetation and channel morphology can occur from fishing activities, such as damage to the stream bank from boat wakes and removal of woody debris to provide access. Trampling of stream banks and the stream channel can also damage salmon habitat. Where use levels are high, this type of impact may require restoration or management initiatives. An example is the Kenai River where restoration work was needed to repair damage from recreational fishing for chinook salmon and other salmonids.

Summary of the Impacts of Fishing on Habitat

Alterations to natural communities are inevitable when harvesting marine organisms with any gear type. The removal of any organism has , by itself, an effect. It has been suggested that though there is some alteration due to fishing, it is simply a necessity to harvest the resource (de Groot 1984). Furthermore, some studies have shown that the community will return to relatively pristine conditions in a relatively short time period following a fishing closure, if there was an effect at all (Graham 1955; van Dolah et al. 1987; Rumohr and Krost 1991; Jones 1992; Brylinsky et al. 1994). On the other hand, there is also the suggestion that pre-fishing, “pristine” conditions are not known, since almost all study areas have had some form of fishing prior to the study (Auster et al. 1996). Lastly, there are also studies that conclude that trawling, in some situations, may cause long-term changes in habitat and community structure (Auster et al. 1996; Kaiser and Spencer 1996b; Schwinghamer et al. 1996).

To further confuse the issue, nothing is static. The fishing industry makes regular alterations to gear and fishing techniques. The oceanic and atmospheric conditions change continually, on both local and global scales, all of which may affect groundfish or the benthic communities upon which they depend. Lastly, other human induced actions such as pollution, mining and petroleum exploration can affect benthic communities as well. However, declines of some fisheries being observed around the world have served to emphasize that all sources of potential effects should be considered by managers aiming for sustainability.

Table 9.2 Summary of literature cited. Those studies done in Alaska are shown in bold.

Authors	Year	Gear Type	Location	Fishery	Main Emphais of Citation
Apollonio	1989	Otter Trawl	Northwest Atlantic	Groundfish	Habitat and Benthic Alterations
Armstrong, et. al.	**1993**	**Bottom Trawl**	**Bering Sea**	**Groundfish**	**Bycatch**
Auster, et.al.	1996	Otter Trawl	Gulf of Maine	Groundfish	Habitat and Benthic Alterations
BEON-Rapport 8	1990	Beam Trawl	North Sea	Groundfish	Habitat and Benthic Alterations
Bergman and Hup	1992	Beam Trawl	North Sea	Groundfish	Habitat and Benthic Alterations
Bergman, et. al.	1989	Beam Trawl	North Sea	Groundfish	Habitat and Benthic Alterations
Blackburn and Schmidt	**1988**	**Otter Trawl**	**GOA (Kodiak area)**	**Survey**	**Bycatch**
Brylinsky, et. al.	1994	Otter Trawl	Bay of Fundy	Flounder	Habitat and Benthic Alterations
Caddy	1973	Otter Trawl	Gulf of St. Lawrence	Groundfish	Habitat and Benthic Alterations
Churchill	1989	Otter Trawl	Mid-Atlantic Bight	Groundfish	Sediment Resuspension
de Groot	1984	Beam+Otter Trawl	North Sea	Groundfish	Habitat and Benthic Alterations
Efanov and Istomin	1988				Bycatch
Fonds, M.(ed.)	1991	Beam Trawl	North Sea		Bycatch
Fukuhara and Worlund	1973	Otter Trawl	Bering Sea	Groundfish	Bycatch
Gibbs, et. al.	1980	Otter Trawl	New South Wales	Shrimp	Habitat and Benthic Alterations
Graham	1955	Otter Trawl	North Sea	Plaice	Habitat and Benthic Alterations
Heifetz (ed.)	1997	Otter Trawl	BSAI/GOA	Groundfish	Habitat and Benthic Alterations
Hill and Wassenberg	1990	Otter Trawl	South Pacific	Shrimp	Bycatch
Hutchings	1990	Otter Trawl	Australia	Shrimp	Habitat and Benthic Alterations
Jones	1992	Beam +Otter Trawl	World Wide	Multiple	Habitat, Bycatch, Alterations
Kaiser and Spencer	1994				Bycatch
Kaiser and Spencer	1996	Beam Trawl			Bycatch
Kaiser and Spencer	1996	Beam Trawl	Europe Shelf	Groundfish	Habitat and Benthic Alterations
Ketchen	1947	Otter Trawl	Western N. Atlantic	Groundfish	Habitat and Benthic Alterations
Krost, et. al.	1990	Otter Trawl	Western Baltic	Groundfish	Habitat and Benthic Alterations
Main and Sangster	1988	Otter Trawl	North Atlantic	Groundfish	Bycatch
Mayer et.al.	1991	Otter Trawl	Gulf of Maine	Groundfish	Sediment Resuspension
McAllister	1991	Trawls (in general)	World Wide	Groundfish	Habitat and Benthic Alterations
Messieh, et.al.	1991	Otter Trawl	Eastern Canada	Groundfish	Habitat and Benthic Alterations
NRC	**1988**	**Otter Trawl**	**Bering Sea**	**Groundfish**	**Bycatch**
Owen	**1988**	**Otter Trawl**	**GOA(Kodiak area)**	**Survey**	**Bycatch**
Rumohr and Krost	1991	Trawls (in general)	Western Baltic	Groundfish	Habitat and Benthic Alterations
Russell	1997	Trawls (in general)	Georges Bank	Groundfish	Habitat and Benthic Alterations
Sangster	1992				Bycatch
Schwinghamer et.al.	1996	Otter Trawl	Grand Banks	Groundfish	Habitat and Benthic Alterations
Stevens	**1990**	**Otter Trawl**	**Gulf of Alaska**	**Sole**	**Bycatch**
Suuronen et.al.	1993				Bycatch
van Beek et.al.	1989	Otter+Beam Trawls	North Sea	Flatfish	Bycatch
van Dolah et.al.	1987	Roller Trawl	Coast of Georgia	Survey	Habitat and Benthic Alterations
Williams	**1997**	**Otter Trawl**	**BSAI/GOA**	**Groundfish**	**Bycatch**

9.2.2 Current Research on Fishing Gear and Habitat Interactions in the North Pacific

Habitat can be considered as the biotic-abiotic interface. This view is a composite of several terms including habitat (physical locality), ecological niche (environmental conditions), and biotope (location plus environmental conditions suitable for particular species). A few general principles underlie much of habitat (actually *biotope*) research: (1) a single species is not ubiquitous, thus habitat is restrictive; (2) a species is not uniformly distributed throughout its area of occurrence, thus habitat quality varies; and (3) there is significant temporal variability in habitat quality and location. In general, fish abundance reflects habitat quality. Because fish are able to select habitat, the best habitat is occupied first and at the highest density, while marginal areas are eventually occupied in response to crowding . As such, relative abundance is a reasonable first approximation of habitat quality.

Current research includes environmental data collection, habitat characterization, environmental impacts of fishing, and analysis of community ecology. New technology (acoustic bottom typing, laser line systems and GIS) may allow for much improved data collection and analysis. Acoustic bottom typing enables passive collection of sea floor attributes during fishing and/or survey operations. Laser line systems function much like a towed camera system but it is useable in somewhat more turbid conditions. Habitat characterization research has focused on identifying limits and preferences of fish species, incorporating the effects of population size and describing associations with surface sediments. An investigation into the environmental impacts of bottom trawling in the Bering Sea was initiated last year. Comparison of heavily fished and unfished areas in Bristol Bay will assess chronic exposure effects. Experimental trawling in unfished areas in 1997 and beyond will provide information on acute exposure effects and the recovery process will be monitored. These studies will enable resource managers to evaluate the efficacy of time-area closures in soft-bottom areas. Similar studies are being conducted in harder bottom areas of the Gulf of Alaska using a submersible and video assessment technology. Additional planned studies include a retrospective analysis for the Gulf and a field study of trawl impacts in gorgonian coral habitat in the Aleutians. Potential changes in Bering Sea community ecology will be examined by comparing current fish assemblages with those identified in an earlier (1982) study. Habitat research bottlenecks include the limited seasonal coverage of data collection, the general paucity of environmental data, frequently inconsistent data formats and potentially high data processing costs (e.g., infauna and video). There are additional resource constraints related to manpower and short-term funding cycles.

Alaska Fisheries Science Center (AFSC) Sea Floor Habitat Research

In 1996 the AFSC initiated studies specifically address the potential effects of fishing on the seafloor, benthic organisms and their habitat. The studies were directed at investigating the effect of fishing on the sea floor and evaluation of technology to determine bottom habitat type. A summary of the 1996 and 1997 studies and plans for 1998 are given below:

Research in 1996 and 1997:

Experimental Trawling in the Eastern Gulf of Alaska. A chartered manned submersible and chartered commercial trawl vessel were used to quantify changes to the sea floor caused by bottom trawling. Specific objectives were to document changes to epifauna and physical attributes to the sea floor caused by bottom trawling with tire-gear. The experiment took place in the Eastern GOA in rockfish habitat over hard bottom substrate during July and August 1996. Video footage was obtained from 10 trawl paths, including seven single tow paths, two triple tow paths and one seven tow path. Analysis of the videotape data focuses on habitat classification, sessile and motile epifauna in trawled versus untrawled transects, damage to epifauna, and comparisons of trawl bycatch with organisms in situ. Study sites were marked so that observations could be repeated in 1997.

In 1997, the 1996 submersible transects were repeated to document effects on seafloor habitat one year after trawling. In addition, the submersible was used in 1997 to observe trawl impacts on red tree coral, *Primnoa* spp. A trawl path was located at 365 m depth in Dixon Entrance where 2 t of red tree coral was caught during a 1990 trawl survey. The trawl path was identified by moved boulders and broken coral. Damage and abundance of coral in the trawl path will be compared to areas outside the trawl path.

Preliminary analysis of data collected in 1996 has been completed. The seafloor substrate at the experimental sites consisted of 92% pebble, 6% cobble and 2% boulder. The trawl path could be identified by furrows in the substrate 1-8 cm deep caused by the tire gear attached to the trawl foot rope. A total of 30 species (or larger taxonomic groups) of invertebrates were identified from the video. These species were categorized into sessile and motile groups. The seven sessile species were considered to provide “structural components of habitat”, because together with the boulders, they provided the only three dimensional relief on the sea floor. The sessile species were combined into four groups: three species of large erect sponge, morel sponge, finger sponge, and anthozoans (sea whips and anemones). The motile species were combined into five groups: asteroids, echinoids, holothurians, molluscs and arthropods.

Densities of undamaged large erect sponges, morel sponges, and anthozoans were significantly lower in trawled sites compared to reference sites. Densities of the small finger sponges were not significantly affected by trawling. Extensive incidences of damage were detected for the three species of large erect sponges, and for sea whips, but not for morel sponges, finger sponges or anemones. No significant differences in density of motile groups were detected, though the densities of arthropods and molluscs tended to be greater in trawled sites, possibly because of a scavenging response to disturbance by the trawl. No significant damage due to trawling was detected for any of the motile groups, with the exception of brittle stars. Trawl bycatch, as a percentage of individuals present in reference transects, were calculated for spot prawns (46%), asteroids (<1%), echinoids (<1%), holothurians (5%), and molluscs (<1%).

Trawl Effects in the Eastern Bering Sea. Experimental trawling was conducted in 1996 in the BS to improve understanding of the effects of bottom trawls on the soft-bottom benthos. Samples were collected with a NMFS 83-112 bottom trawl modified to improve retention of epifauna. In this study, epifauna are assumed to be indicators of sea floor attributes, given characteristically strong affinities for particular substrates. An historical analysis of commercial bottom trawl effort in the BS (1933-95) identified adjacent pairs of heavily fished and unfished 1 nmi^2 areas of the sea floor. Population densities and community structure in the two groups of stations will be compared. A color video system was attached to the experimental trawl and provided additional information on habitat features. In addition to inferences about trawl-related effects, this research will provide important information about the spatial variability in benthic communities and will serve as the basis for more rigorous manipulative investigations in the future.

During 1997 a GIS-based experimental design was developed to contrast biological and geological conditions before and after trawling with commercial gear and, if impacts were detected during 1997, to continue monitoring in subsequent years. Infauna samples were collected at an experimental (n=15) and a control (n=15) site during the pre-trawling phase. Additionally, sidescan sonar and video surveys were conducted in the experimental site, to characterize and identify sea floor attributes prior to trawling. Epifauna sampling and the trawling treatment will take place pending successful deployment of gear tracking - navigation system requisite to the experimental design.

Also in 1997, to evaluate potential chronic effects of trawling on infauna populations heavily fished and unfished stations (n=25 pairs), occupied during the 1996 study of epifauna, were quantitatively sampled with the 0.1 m^2 Sutar van Veen grab. Taxonomic processing of the samples is underway, under contract with the University of Alaska Fairbanks. Sidescan sonar and video surveys on both sides of the closed area boundary (58^o N., NE corner of management area 512) revealed sand waves, indicative of extensive reworking of the bottom by currents, as well as linear marks possibly caused by trawls. A sidescan reconnaissance survey in the very heavily fished Unimak “cod corridor”, characterized by harder substrates than the Bristol Bay sites, was also conducted.

Retrospective Analysis of Commercial Trawl Data and Benthic Community Structure. The objectives of this study are to utilize commercial trawl fishery data and trawl survey data to 1) describe the geographic and temporal patterns of trawl fishery effort in the GOA and Aleutian Island (AI) regions, 2) describe the major benthic communities by their component species and associations based on trawl survey data, and 3) to the extent possible, determine possible trawl fishery influences on benthic community structure by comparing benthic community structure in heavily trawled areas to lightly trawled areas. This study, initiated in 1996, is carried out via a grant to the Cooperative Institute for Arctic Research (CIFAR) at the University of Alaska, Fairbanks (UAF).

The spatial and temporal patterns of bottom trawl effort in the Gulf of Alaska (GOA) and Aleutian Islands (AI) were analyzed from 1990-1997. Haul data were from the National Marine Fisheries Service (NMFS) domestic observer database (NORPAC) and include gear type, latitude, longitude, and NMFS regulatory and reporting areas. Trawl locations were plotted annually and cumulatively by management areas in a geographical information system (ARCVIEW-GIS) map to aid in analysis of spatial and temporal patterns. Preliminary analyses have been conducted. Areas of high bottom trawl effort within the GOA occur in the Kodiak region where there have been directed fisheries targeting on Pacific ocean perch (*Sebastes alutus*), Pacific cod (*Gadus macrocephalus*), and flatfish. The Aleutian Island has had high trawl efforts for Atka mackerel (*Pleurogrammus monopterygius*) and Pacific ocean perch. The total numbers of observed tows, average tow time, and range of tow time for the years 1990-1997 have been computed for the GOA and the AI.

Changes in benthic assemblages in relation to trawl effort will be studied in the next phase of the study. Benthic community structure will be described from a database (RACEBASE), composed of species abundance and biomass from NMFS triennial and annual research surveys in the GOA and AI regions. Principal coordinate analysis will be applied to the species data and environmental parameters, including depth or strata.

<u>Evaluation of Technology to Determine Bottom Habitat Type</u>. Knowledge of the extent and distribution of different habitat types is necessary to make informed evaluations of the potential impact of fishing activity on seafloor habitat. Efficient methods to determine and describe bottom habitat are needed to obtain this information.

Laser line scan systems (LLSS) and hydroacoustic bottom typing systems were used in 1996 in areas that have been ground truthed. Data collected with LLSS was compared with historical (1991-1995) video and side scan sonar imagery over a well known area of bottom at depths similar to where trawl fisheries commonly occur. Also the feasibility of using LLSS to detect trawl tracks on the sea floor was evaluated. Trawl tracks were difficult or impossible to observe in well sorted sand mixed with shell hash, more easily observed in sand/silt mud bottom and clearly observable in soft bottom. The LLSS appears to fill a gap between side scan sonar and ROVs, is easily deployed and capable of observing some effects of trawling. An acoustic bottom typing system (QTC View Series 3, manufactured by the Quester Tangent Corporation, Sidney, B.C.) was used to begin an evaluation of the efficacy of remote sensing of sea floor properties in soft bottom areas of the BS and hard bottom areas of the GOA.

In 1997 the QTC system was deployed from the *Miller Freeman* during gear trials in Puget Sound and again in the Bering Sea during a routine hydroacoustic assessment of pollock (covering nearly 10,000 miles). In both cases, a classification catalog was developed and ground truth samples collected. Grab samples were also collected to evaluate the accuracy of the acoustic classifications. Also, selected tracklines were repeatedly surveyed to evaluate classification precision and potential effects of vessel speed. Finally, data sets were simultaneously collected at two frequencies using two *QTC View* systems and another more sophisticated hydrographic survey instrument (*ISAH-S*) to enable determination of optimum parameters for sea floor classification in the Bering Sea. A greatly refined *Series 4* has been developed by the QTC, with a feature set based heavily on AFSC experiences and research needs. A leased unit was evaluated in the Gulf of Alaska during summer 1997 aboard the NOAA ship *John Cobb* using a navigational echosounder (Simrad *EQ-50*). Analysis and a report detailing these results will be completed in FY 1998.

Workshop on Potential Effects of Fishing Gear on Benthic Habitat. About 30 individuals participated in a Sept. 1996 workshop including scientists from the Alaska Fisheries Science Center, NMFS Alaska Regional Office, U.S. Geological Survey, Alaska Department of Fish and Game (ADF&G), UAF, University of Washington (UW), and the National Undersea Research Center. The primary objectives of this workshop were to review the progress and preliminary results of studies initiated in 1996 and to discuss approaches and priorities for proposed research for 1997. Presentations included preliminary observations from a manned submersible of trawl effects on hard bottom areas in the Eastern GOA, an overview of field studies to examine bottom trawl effects in the BS, a description of methods to be used to examine benthic community structure and possible effects of trawling based on historical data in the GOA and AI, and video footage of how different types of trawl gear can effect seafloor habitats. Additional presentations included a review of fishing gear effects studies off the northeast United States and preliminary evaluations of the feasibility of using laser line scan systems, sidescan sonar, and hydroacoustic habitat mapping systems as research tools to examine fishing gear effects.

Effects of Trawling on Hard Bottom Habitat in the Aleutian Islands - Late in FY 1997, a project to study the effects of trawling on gorgonian coral habitat in the Aleutian Islands was initiated. Gorgonian corals were once a major component of the bycatch of the Atka mackerel fishery in Seguam Pass in the Aleutian Islands. However, after twenty years of intense fishing effort coral is now infrequently caught. The studies objectives are: 1) examine whether the corals in the heavily trawled areas of Seguam Pass are more damaged and less abundant than in nearby, less trawled, areas; and, 2)investigate whether fish and invertebrates use coral forests for shelter. The first year of the project was devoted to design and procurement of components needed to construct the towed camera body system. A system is currently being assembled which is patterned after the TACOS system developed by the Australian CSIRO Laboratory out of Hobart, Australia to study impacts on coral reefs. The system will be tested in Puget Sound or southeast Alaska in the late winter or spring of 1998.

AFSC Research Planned for 1998

A Description of Seafloor Habitat in a Heavily Trawled Region and a Protected Region of the Central Gulf of Alaska In 1986 the North Pacific Fisheries Management Council closed an area known as Marmot Flats near Kodiak, Alaska to bottom trawling. This area, encompassing 1500 km^2, was designated as an important rearing area and migratory corridor for juvenile and molting crabs. The closure is intended to assist in rebuilding severely depressed crab stocks by providing sanctuary to 85% of the Kodiak Island area red king crab stocks and 75% of the Tanner crab stocks. In addition to the crab resources, this area and the area immediately adjacent to it, have extremely rich stocks of groundfish including flathead sole, butter sole, Pacific halibut, arrowtooth flounder, Pacific cod, and several species of demersal rockfish. Consequently, the area immediately adjacent to the closure area is trawled extensively.

This closure provides a unique opportunity to study the effects of bottom trawling on a productive soft-bottomed marine ecosystem. Direct comparisons can be made between an area which is consistently trawled each year and an area where bottom trawling has been prohibited for at least twelve years. The proximity of the areas should allow for detection of fine-scale changes in infaunal and epifaunal composition, and microhabitat structure and abundance.

Use of a manned submersible is planned to assess changes to the seafloor caused by chronic trawling. Systematic video transects would be made along similar isobaths in the two areas. Controlling for depth should minimize diversity among epibenthic and infaunal species assemblages, and substrate composition. The seafloor habitat in both areas will be described in detail. All macrofauna, and physical characteristics of the seafloor will be quantified. Data from a minimum of twenty transects would be collected within each area. A sediment sample from each transect would be collected and analyzed for grain-size, and infaunal diversity and composition.

<u>Continuation of trawling effects studies in the Eastern Bering Sea.</u> The experimental approach adopted for a phase of this study requires exact real-time information on the position of both research and commercial trawls. During 1997 co-investigators with USGS were unable to provide this information with their equipment. In order to identify the proper equipment with the capability to provide this information, various alternatives will be evaluated in 1998.

During 1998, gear trials in Puget Sound will be conducted under conditions similar to those at the Bering Sea study sites. Three manufacturers will demonstrate gear tracking systems. Performance of each system will be evaluated by comparing system-based trawl positions with very accurate (<2-3 meters) determinations made by the test range. An independent consultant will plan, conduct and report test results. A representative commercial fishing vessel will be chartered for 12 days during which time each vendor will be given an opportunity to install and calibrate their equipment prior to standardized testing. Manpower and equipment costs directly related to the product demonstrations are the responsibility of each manufacturer. A mutually acceptable over-the-side transducer mount will be provided by the Government, as will all cabling between the transducer mount and the manufacturer supplied video display/navigation software in the wheelhouse. After completion of the analyses, test results will be submitted for publication in a peer-reviewed journal.

<u>Continued Evaluation of Technology to Determine Bottom Habitat Type</u>. The digitized echo returns collected in 1997 in the eastern Bering Sea using a QTC *ISAH-S* hydrographic instrument aboard the *Miller Freeman* will be analyzed by the QTC using proprietary methods. Results of these analyses will be used to optimize a *QTC View* acoustic sea floor classification system for the eastern Bering Sea. Simultaneous processing of *ISAH-S* data for an entire survey will greatly accelerate the otherwise iterative process of refining a *QTC View* classification catalog. The “raw” nature of the *ISAH-S* data also permits systematic evaluations of various hard coded options in the *QTC View* signal processing and sea floor classification algorithms which can then be optimized for a particular environment.

Specific objectives/deliverables include: (1) Phased processing of all *ISAH-S* data collected during the summer 1997 cruises of the *Miller Freeman* (38 and 120 kHz); (2) determine the optimum parameters for acoustic classification of the Bering Sea sea floor data; (3) evaluate the data to determine the optimum operational scenario for the *QTC View* system (*e.g.*, number of classification catalogs and number of substrate classes in each); (4) generate a habitat classification map and identify locations for calibration of the *QTC View* system; and (5) deliver a specially configured *QTC View Series 4* (upgrade), incorporating optima determined above. After these objectives are met, the *Miller Freeman*, chartered survey vessels or any other ships of opportunity will be able to create an optimum classification catalog and begin collecting synoptic data characterizing the eastern Bering Sea sea floor using a *QTC View* system.

Continuation of Effects of Trawling on Hard Bottom Habitat in the Aleutian Islands. Funding received in FY 1997 for this project was used to design and procure the components for the underwater towed camera body to be used for the project. All components and most of the supplies for the FY 1998 field work have been purchased and the towed system is being assembled. In FY 1998, the towed system will be tested in either Puget Sound or southeast Alaska to determine how it performs in areas of rough bottom and strong currents. The testing will be completed in late winter or spring of 1998. Once it is demonstrated that the towed system will perform as designed, the system will be deployed in Seguam Pass in the Aleutian Islands for 7 days in the summer of 1998 to record video observations of trawled and untrawled areas of gorgonian coral habitat and to investigate the utilization of those areas by key species of fish and invertebrates. The performance of the towed camera body will be evaluated and video observations analyzed and reported on in late 1998 or early 1999.

9.2.3 Literature of Scientific Studies on Fishing Threats to Habitat

Apollonio, S. 1989. Eliminating otter trawls could be key to better fisheries management. National Fisherman, Nov. :34-35.

Armstrong, D.A., T.C. Wainwright, G.C. Jensen, P.A. Dinnel, and H.B. Anderson. 1993. Taking refuge from bycatch issues: red king crab (Paralithodes camtschaticus) and trawl fisheries in the eastern Bering Sea. Canadian Journal of Fisheries and Aquatic Science 50:1993-2000.

Aschan, M.M. 1991. Effects of Iceland scallop dredging on benthic communities in the Northeast Atlantic. Special international workshop on the effects of physical disturbance on the sea floor on benthic and epibenthic ecosystems. Conseil International pour L'Exploration de la Mer, Benthos Working Group Manuscript.

Auster, P.J., and R.W. Langton. 1998. The Indirect Effects of Fishing. American Fisheries Society, unpublished manuscript.

Auster, P.J., R.J. Malatesta, R.W. Langton, L.Watling, P.C. Valentine, C.L.S. Donaldson, E.W. Langton, A.N. Shepard, and I.G. Barr. 1996. The impacts of mobile fishing gear on sea-floor habitats in the Gulf of Maine (Northwest Atlantic): Implications for conservation of fish populations. Reviews in Fisheries Science 4(2): 185-202.

Barnhart, J.P., I.W. Vining, and L.C. Byrne. 1996. A summary of data collected by scallop observers from the 1994/1995 commercial scallop fishery in Alaska's Westward Region. Alaska Department of Fish and Game Regional Information Report 4K96-33.

BEON-RAPPORT 8. 1990. Effects of Beam-trawl Fishery on the Bottom Fauna in the North Sea. p 57.

Bergman, M.J.N. and M. Hup. 1992. Direct effects of beam-trawling on macrofauna in a sandy sediment in the southern North Sea. ICES Journal of Marine Science 49:5-11.

Bergman, M.J.N. et al. 1989. Direct effects of beam-trawl fishing on benthic fauna in the North Sea. Netherlands Institute for Sea Research, Beo-Rapport, 8.

Blackburn J., and D. Schmidt. 1988. Injury and apparent mortality rates from incidental trawl catches of halibut, king crab, and Tanner crab in the Kodiak area, 1977-81. Alaska Department of Fish and Game Regional Information Report 4K88-21.

Brylinsky, M., J. Gibson, and D.C. Gordon Jr. 1994. Impacts of flounder trawls on the intertidal habitat and community of the Minas Basin, Bay of Fundy. Canadian Journal of Fisheries and Aquatic Sciences 51: 650-661.

Butcher, T., J. Matthews, J. Glaister, and G. Hamer. 1981. Study suggests scallop dredges causing few problems in Jervis Bay. Australian Fisheries 40:9-12.

Byersdorfer, S. and L.J. Watson. 1992. A summary of biologcial data collected during the 1991 Bristol Bay red king crab tagging study. Alaska Department of Fish and Game Technical Fishery Report 95-14.

Caddy, J.F. 1968. Underwater observations on scallop (Placopecten magellanicus) behavior and drag efficiency. Journal of the Fisheries Research Board of Canada 25: 2123-2141.

Caddy, J.F. 1973. Underwater observations on tracks of dredges and trawls and some effects of dredging on a scallop ground. Journal of the Fisheries Research Board of Canada 30: 173-180.

Caddy, J.F. 1989. A perspective on the population dynamics and assessment of scallop fisheries, with special reference to the sea scallop, *Placopecten magellanicus* Gmelin. Pages 559-589 <u>in</u> J.F. Caddy, editor. Marine invertebrate fisheries: their assessment and management. John Wiley and Sons, New York.

Carls, M.G., and C.E. O'Clair. 1989. Influence of cold air exposures on ovigerous red king crabs (<u>Paralithodes</u> <u>camtschatica</u>) and Tanner crabs (<u>Chionoecetes bairdi</u>) and their offspring. Proceedings of the International Symposium on King and Tanner Crabs. Alaska Sea Grant College Program Report No. 90-04.

Chopin, F.S., and T. Arimoto. 1995. The condition of fish escaping from fishing gears -- a review. Fisheries Research 21:315-327.

Churchill, J.H. 1989. The effect of commercial trawling on sediment resuspension and transport over the Middle Atlantic Bight continental shelf. Continental Shelf Research, 9(9): 841-864.

Collie, J.S., G.A. Escanero, L.Hunke, and P.C. Valentine. 1996. Scallop dredging on Georges Bank: Photographic evaluation of effects on benthic epifauna. ICES C.M. 1996/ Mini: 9, p14.

de Groot, S.J. 1984. The impact of trawling on benthic fauna of the North Sea. Ocean Manage. 9:177-190.

Donaldson, W.E. 1990. Determination of experimentally induced non-observable mortality on red king crab. Alaska Department of Fish and Game Regional Information Report 4K90-13.

Drew, S. C., and R.E. Larsen. 1994. Worldwide Trawl and Dredge Study. Marine Data Systems, Plymouth, MA, USA.

Efanov, S.F. 1981. Herring in the Gulf of Riga: the problem of escapement and mechnical impact of the trawl. ICES CM 1981/J:17.

Efanov, S.F. and I.G. Istomin. 1988. Survival of Alaska pollock and selective properties of trawl codends. ICES CM 1988/B:20.

Eleftheriou, A., and M.R. Robertson. 1992. The effects of experimental scallop dredging on the fauna and physical environment of a shallow sandy community. Netherlands Journal of Sea Research 30: 289-299.

Elner, R.W., and G.S. Jamieson. 1979. Predation on sea scallops, *Placopecten magellanicus*, by the rock crab, *Cancer irroratus*, and the American lobster, *Homarus americanus*. Journal of the Fisheries Research Board of Canada 36: 537-543.

Fonds, M. (ed.). 1991. Measurements of catch composition and survival of benthic animals in beam trawl fishery for sole in the southern North Sea. In, Effects of beam-trawl fishery on the bottom fauna in the North Sea. II: The 1990 studies.

BEON-report 13:53-68.
Fonseca, M.S., G.W. Thayer, A.J. Chester, and C. Foltz. 1984. Impact of scallop harvesting on eelgrass *(Zostera marina)* meadows: implications for management. North American Journal of Fisheries Management 4: 286-293.
Fukuhara, F.M., and D. Worlund. 1973. Incidence of halibut and Tanner crab in catches by the eastern Bering Sea mothership trawl fishery and independent trawlers. NOAA/NMFS Report to the International North Pacific Fisheries Commission.
Gibbs, P.J., A.J. Collins, and L.C. Collett. 1980. Effect of otter prawn trawling on the macrobenthos of a sandy substratum in a New South Wales estuary. Aust. J. Freshwater Res., 31, 1-6.
Graham, M. 1955. Effect of trawling on animals of the sea bed. Pap. Mar. Biolg. Oceanogr. Deep Sea Res. Suppl. 3:1-6.
Hammerstrom, L.F., and M.F. Merrit. 1985. A survey of Pacific weathervane scallops in Kamishak Bay, Alaska. Alaska Department of Fish and Game, Division of Commercial Fisheries, Information Leaflet 252.
Hampton, M.A., P.R. Carlson, H.J. Lee and R.A. Feely. 1986. Geomorphology, sediment, and sedimentary processes. In. D.W. Hood and S.T. Zimmerman (eds), The Gulf of Alaska: Physical Environment and Biological Resources. United States Department of Commerce, NOAA and Department of the Interior, MMS, 93-143.
Heifetz, J. (ed.). 1997. Workshop on the potential effects of fishing gear on benthic habitat. NMFS AFSC Processed Report 97-04. 17 pp.
Hennick, D.P. 1970. Reproductive cycle, size at maturity, and sexual composition of commercially harvested weathervane scallops *(Patinopecten caurinus)* in Alaska. Journal of the Fisheries Research Board of Canada 27: 2112-2119.
Hennick, D.P. 1973. Sea scallop, *Patinopecten caurinus*, investigations in Alaska. Alaska Department of Fish and Game, Division of Commercial Fisheries, Completion Report 5-23-R, Juneau.
Hill, B.J. and T.J. Wassenberg. 1990. Fate of discards from prawn trawlers in Torres Strait. Australian Journal of Marine and Freshwater Research 41: 53-64.
Hsiao, Y.M., J.E. Easley and T. Johnson. 1987. Testing for harmful effects of clam and scallop harvesting techniques in the North Carolina bay scallop fishery. North Amer. J. Fish. Manage. 7:187-193.
Hutchings, P. 1990. Review of the effects of trawling on macrobenthic epifaunal communities. Australian Journal of Marine and Freshwater Research 41: 111-120.
Jamieson, G.S. and A. Campbell. 1985. Sea scallop fishing impact on American lobsters in the Gulf of St. Lawrence. U.S. National Marine Fisheries Service Fisheries Bulletin 83:575-586.
Jones, J.B. 1992. Environmental impact of trawling on the seabed: a review. New Zealand Journal of Marine and Freshwater Research. 26: 59-67.
Kaiser, M.J. and B.E. Spencer. 1994. Fish scavenging behavior in recently trawled areas. Marine Ecology Progress Series, 112:41-49.
Kaiser, M.J. and B.E. Spencer. 1996a. Fish scavenging behavioral response of scavengers to beam-trawl disturbance. In. S.P.R. Greenstreet and M.L. Tasker, Aquatic Predators and their Prey, Blackwell Scientific Publications, Oxford.
Kaiser, M.J. and B.E. Spencer. 1996b. The effects of beam-trawl disturbance on infaunal communities in different habitats. Journal of Animal Ecology. 65: 348-358.
Kenchington, E.L. and M.J. Lundy. 1991. Bay of Fundy stock assessment. CAFSAC Research Document 91/26, 28 p.
Ketchen, K.S. 1947. An investigation into the destruction of ground by otter trawling gear. Prog. Rept. Fish. Res. Bd. Can. 73:55-56.
Krost, P., M. Bernhard, F. Werner, and W. Hukriede. 1990. Otter trawl tracks in Kiel Bay (Western Baltic) mapped by side-scan sonar. Meereforschung 32: 344-353.
MacIntosh, R.A., B.G. Stevens, and J.A. Haaga. 1995. Effects of handling and discarding on mortality of Tanner crabs, Chionoecetes bairdi. Proceedings of the International Symposium on Biology, Management, and Economics of Crabs from High Latitude Habitats. Alaska Sea Grant College Program Report.
MacKenzie, C.L. 1982. Compatibility of invertebrate populations and commercial fishing for ocean quahogs. North American Journal of Fisheries Management 2:270-275.
Main, J., and G.I. Sangster. 1988. Scale damage and survival of young gadoid fish escaping from the Cod-end of a demersal trawl. In: Trawl-net Selectivity and the Survival of Fish Escaping from Cod-ends. National Sea Grant Publication #RIU-W-88-002. p.17-34.
Mayer, L.M., D.F. Schick, R.H. Findlay, and D.L. Rice. 1991. Effects of commercial dragging on sedimentary organic matter. Marine Environmental Research 31:249-261.
McAllister, D. 1991. Questions about the impact of trawling. Sea Wind 5(2):28-33.
McLoughlin, R.J., P.C. Young, R.B. Martin, and J. Parslow. 1991. The Australian scallop dredge: estimates of catching efficiency and associated indirect fishing mortality. Fisheries Research 11: 1-24.
Messieh, S.N., T.W. Rowell, D.L. Peer, and P.J. Cranford. 1991. The effects of trawling, dredging and ocean dumping on the eastern Canadian continental shelf seabed. Continental Shelf Research, 11:1237-1263.
Meyer, T., R.A. Cooper and K.J. Pecci. 1981. The performance and environmental effects of hydraulic clam dredge. Marine Fisheries Review 43:14-22.
Murawski, S.A. and F.M. Serchuk. 1989. Environmental effects of offshore dredge fisheries for bivalves. ICES, Shellfish committee, C.M. 1989/k:27.
Murphy, M.C., and G. H. Kruse. 1995. An annotated bibliography of capture and handling effects on crabs and lobsters. Alaska Fishery Research Bulletin 2(1):23-75.
Naidu, K.S. 1988. Estimating mortality rates in the Iceland scallop, *Chlamys islandica* (O.F. M_ller). Journal of Shellfish

Research (7):61-71.
National Research Council. 1996. The Bering Sea Ecosystem. National Academy Press, Washington, D.C.
NEFMC (New England Fishery Management Council). 1982. Fishery management plan, final environmental impact statement, regulatory impact review for Atlantic sea scallops *(Placopecten magellanicus)*. New England Fishery Management Council, Saugus, Massachusetts.
NEFMC (New England Fishery Management Council). 1988. Amendment #2 to the fishery management plan for Atlantic sea scallops. New England Fishery Management Council, Saugus, Massachusetts.
NMFS (National Marine Fisheries Service). 1987. Cruise results: Assessment of the impact of bottom trawling on crab, other target species and the benthic habitat. Cruise Report 86-01, NWAFC.
NPFMC (North Pacific Fishery Management Council). 1992. Final Supplemental Environmental Impact Statement and Regulatory Impact Review/Initial Regulatory Flexibility Analysis of Proposed Inshore/Offshore Allocation Alternatives (Amendment 18/23) to the Fishery Management Plans for the Groundfish Fishery of the Bering Sea and Aleutian Islands and the Gulf of Alaska. March 5, 1992.
NPFMC (North Pacific Fishery Management Council). 1993. Environmental Assessment and Regulatory Impact of Amendment 37 to the Fishery Management Plans for the Groundfish Fishery of the Bering Sea and Aleutian Islands.
NRC (Natural Resources Consultants). 1988. Minimization of king and Tanner crab bycatch in trawl fisheries directed at demersal groundfish in the Bering Sea. February 1988.
Orensanz, J.M. 1986. Size, environment, and density: the regulation of a scallop stock and its management implications. Pages 195-227 *in* G.S. Jamieson and N. Bourne, editors. North Pacific workshop on stock assessment and management of invertebrates. Canadian Special Publication of Fisheries and Aquatic Sciences 92.
Owen, D. 1988. A bottom trawl survey on the west side of Kodiak Island: Viekoda Bay, Spiridon Bay, and Kupreanof Strait. Alaska Department of Fish and Game Regional Information Report 4K88-28.
Peterson, C.H., H.C. Summerson & S.R. Fegley. 1987. Ecological consequences of mechanical harvesting of clams. Fish. Bull. 85: 281-298.
Queirolo, L.W., L. Fritz, P.A. Livingston, M.R. Loefflad, D.A. Colpo, and Y.L. deRenier. 1995. Bycatch, Utilization, and Discards in the commercial groundfish fisheries of the Gulf of Alaska, Eastern Bering Sea, and Aleutian Islands. NOAA Tech memo NMFS-AFSC-58.
Reise, K. 1982. Long-term changes in the macrobenthic invertebrate fauna of the Wadden Sea: are polychaetes about to take over? Netherlands Journal of Sea Research 16:29-36.
Rumohr, H., and P. Krost. 1991. Experimental evidence of damage to benthos by bottom trawling with special reference to *Arctica islandica*. Meeresforschung 33: 340-345.
Russell, D. 1997. As trawling goes into high gear, undersea coastal habitat is being razed to the ground. Amicus Journal. Winter:21-25.
Sangster, G. 1992. The survival of fish escaping from fishing gears. International Council for the Exploration of the Sea CM 1992/B:30.
Schwinghamer, P., J.Y. Guigne, and W.C. Siu. 1996. Quantifying the impact of trawling on benthic habitat structure using high resolution acoustics and chaos theory. Canadian Journal of Fisheries and Aquatic Sciences 53: 288-296.
Shepard, A.N. and P.J. Auster. 1991. Incidental (non-capture) damage to scallops caused by dragging on rock and sand substrates. In: Shumway, S.E. and Sandifer (eds.) An International Compendium of Scallop Biology and Culture. World Aquaculture Workshops, #1, The World Aquaculture Society, Louisiana State University, Baton Rouge. pp. 219-230.
Stevens, B.G. 1990. Survival of king and Tanner crabs captured by commercial sole trawls. Fishery Bulletin, 88:731-744.
Stevens, B.G., and R.A. MacIntosh. 1993. Survival of crabs discarded from commercial pot fisheries. Cited in Queirolo et al. 1995. Bycatch, Utilization, and Discards in the Commercial Groundfish fisheries of the Gulf of Alaska, Eastern Bering Sea, and Aleutian Islands. NOAA Technical Memorandum NMFS-AFSC-58.
Suuronen, P., E. Lehtonen, V. Tschernij, and A. Orrensalo. 1993. Survival of Baltic herring escaping from a trawl codend and through a rigid sorting grid. ICES CM 1993/B:14.
Tracy, D. 1994. Biological summary of the 1992 mandatory shellfish observer program database. Alaska Department of Fish and Game Regional Information Report 4K94-10.
Urban, D., D. Pengilly and I.W. Vining. 1994. The scallop observer program and statewide data analysis summary to the Board of Fisheries. Alaska Department of Fish and Game Regional Information Report 4K94-28.
van Beek, F.A. et al. 1989. On the survival of plaice and sole discards in the otter trawl and beam trawl fisheries in the North Sea. ICES CM 1989/G:46.
van Dolah, R.F., P.H. Wendt and N. Nicholson. 1987. Effects of a research trawl on a hard bottom assemblage of sponges and corals. Fisheries Research 5: 39-54.
Watson, L.J., and D. Pengilly. 1994. Effects of release method on recovery rates of tagged red king crabs (Paralithodes camtschaticus in the 1993 Bristol Bay commercial fishery. Alaska Department of Fish and Game, Commercial Fisheries Management and Development Division, Regional Information Report 4K94-40.
Williams, G. H. 1997. Pacific halibut discard mortality rates in the 1990-1996 Alaskan groundfish fisheries, with recommendations for monitoring in 1998. In: Preliminary Stock Assessment and Fishery Evaluation Report for the Groundfish Resources of the Bering Sea/Aleutian Islands Regions. NPFMC 1997.
Zheng, J. M.C. Murphy, and G.H. Kruse. 1995a. Overview of population estimation methods and robust long-term harvest

strategy for red king crabs in Bristol Bay. Alaska Department of Fish and Game Regional Information Report No. 5J95-21.

Zhou, S. and T.C. Shirley. 1995a. Is handling responsible for the decline of the red king crab fishery? Proceedings of the International Symposium on Biology, Management, and Economics of Crabs from High Latitude Habitats. Alaska Sea Grant Program Report (in press).

Zhou, S. and T.C. Shirley. 1995b. Effects of handling on feeding, activity, and survival of red king crabs, Paralithodes camtschaticus (Tilesius, 1815). Journal of Shellfish Research 14:173-177.

9.2.4 Studies and Management Measures to Protect Habitat in Other Regions

South Atlantic and Gulf of Mexico

Longlines: Bottom longlines used to be one of the principle gears used to target snappers, groupers, wreckfish and other species in the Southeast U.S., and particularly within the jurisdiction of the South Atlantic Council (SAFMC). That Council's area of authority encompasses habitat ranging from the coral reefs of South Florida to the large expanses of sand and mud habitat with occasional rock and "live bottom" outcroppings and ledges off the coast of Georgia, South Carolina, and North Carolina. Between 1991 and 1997, significant restrictions were placed on the use of bottom longlines as part of Amendments 3 through 9 to the FMP for Snappers/Groupers. Pelagic longlines are used for a number of species in the region and are managed under different regulations.

One restriction that was developed in Snapper/Grouper Amendments 4 prohibited the use of bottom longlines for wreckfish, now exclusively a deep water vertical hook and line fishery (300-400 fathoms). The prohibition was implemented because of gear conflicts and potential for habitat damage as stated in the Council plan. The plan provides the following rationale:

Longline cable on the bottom has the potential to break some of the ledges, overhangs and associated organisms, and otherwise damage the habitat on which the wreckfish depend. Habitat damage caused by the longlines would violate the SAFMC habitat policy and should be avoided (SAFMC Amendment 4 to the Snapper/Grouper Plan, pg.53). In 1992, the SAFMC prohibited the use of bottom longlines to fish for snappers, groupers, sea basses, and other finfish in the complex in South Atlantic waters inside of 50 fathoms. The following habitat protection rationale was offered by the SAFMC:

Habitat damage and intense competition among users are problems that arise when longline gear is used within 50 fathoms where significant live bottom occurs and where competition with other hook and line vessels occurs. The Council concluded that this gear is appropriate for use in the deep-water snowy grouper/tilefish fishery where much of the bottom is mud with sparse live bottom areas (pg 55, SAFMC Amendment 4 to the FMP for Snapper/Groupers). And on page 56: "This regulation essentially segments the mid-shelf and the deep-water complex to the bottom longlines. This measure was supported during the public hearing process and the Council concluded that prohibiting use of longline gear within 50 fathoms will prevent the problems of habitat damage and intense competition while at the same time allow fishermen using this gear to continue fishing in deeper water. This action effectively limits longlines to targeting the deep water component of the snapper grouper fishery and keeps the use of longlines outside of the rough bottom habitat." More recently, for enforcement reasons, the South Atlantic Council prohibited fishing with bottom longline gear for nearly all species in the Snapper/Grouper complex, the single exceptions are tilefish and snowy grouper which are found in mud and sand areas with little sensitive habitat (Snapper/Grouper Amendment 6).

The Gulf of Mexico Council has partially followed the SAFMC's lead on prohibiting bottom longlines inside of 50 fathoms. Prohibitions in the waters of the Gulf of Mexico are in state waters in Florida and in federal waters within habitat protection areas. It is noteworthy that in nearly all South Atlantic and Gulf of Mexico waters, the relatively flat continental shelf means that depths do not exceed 50 fathoms until at least 30 to 70 miles from the coastline. The shelf off South Florida is an exception, however, where depths greater than 50 fathoms can be reached within 3-10 miles of the coastline.

Fish Pots and Traps: Fish pots have been used in the South Atlantic and Gulf of Mexico to target black sea bass as well as numerous snapper and grouper species. The most extensive restrictions placed on fish traps were been put in place in state of Florida and federal waters managed by the South Atlantic

Council. In 1991, the SAFMC approved restrictions on the use of baited and non-baited fish pots and traps as part of Amendment 4 to the Council's Snapper/Grouper FMP. Fish pots for snapper and grouper were prohibited in all waters, with one exception for the use of pots for black sea bass north of Cape Canaveral (with a 2 ft by 2ft by 3 ft maximum size restriction for pots). The stated rationale in Amendment 4 for taking such an action was as follows:

There is some evidence that fish trapping causes habitat damage where fish traps are set in "trawls" on live bottom and where grappling hooks are dragged across live bottom to retrieve them. Testimony and video records of damaged Oculina reefs off Palm Beach County, Florida shown to the Council at the February 1991 meeting, depicted significant and measurable damage to coral reef and live bottom communities. These activities leave an imprint of the trap upon the bottom communities and trenches caused by grappling hooks dragged over the bottom for the purpose of locating and recovering traps. Lost traps not only continue to fish, as it has been pointed out in the ghost trap discussion, but may contribute secondary habitat damage by becoming mobilized at times of storm activity and impacting delicate bottom communities. These problems cannot be alleviated by trap design modifications even if such modifications could be enforced. (SAFMC's Snapper/Grouper Plan, Amendment 4. April 1991 page 73-74). Concerns over ghost fishing and data showing that fish pots were taking an excessive share of the harvest from traditional gears were also reasons for the SAFMC's actions to ban fish pots.

While the Gulf of Mexico Council opted not to adopt parallel regulations in the face of the South Atlantic's prohibition on fish pots, the Gulf Council concurrently placed size, area, and number restrictions on the use of fish pots, partly for habitat protection objectives. South Atlantic and Gulf of Mexico Council documents cite information used to back their restrictions on fish pots and longlines. Often, evidence presented to the Council from underwater videos (probably available from SAFMC) is cited as well as scientific studies.

Literature from Other Regions

Bohnsack, J.A., D.L.Sutherland, D.E.Harper, D.B. McClellan, M.W.Hulsbeck and C.M.Holt 1989. The effects of fish trap mesh size on reef fish catch off southeastern Florida. Marine Fisheries Review 51(2):36-46.

Cofer-Shabica, S.V. 1989 Fish traps in the coral reefs of South Florida. In: Proc. Sixth Symp. On Coastal and Ocean Management, Coastal Zone 1989, 4:3030-3044

GMFMC 1983. Gulf of Mexico Fishery Management Council. Amendment Number 7 and Environmental Assessment and Regulatory Impact Review to the Fishery Management Plan, for the Reef Fish Fishery of the Gulf of Mexico.

Harper, D.E., J.A. Bohnsack, D.B. McClellan 1990. Preliminary report on bycatch from the southern Florida wire fish-trap fishery. NMFS SEFC Miami, Florida. MIA-89/90-19. 23pp.

Huntsman, G.R. 1993 Development of management options combining quotas and marine reserves for deep reef species in the jurisdiction of the South Atlantic Fishery Management Council. DOC/NOAA/NMFS/SEFSC. Beaufort Lab, 101 Pivers Island Toad, Beaufort, NC 28516. Unpubl. Ms. 5pp.

Kitner, K.R. 1989. Fish trapping in the South Atlantic: Report to the South Atlantic Fishery Management Council, Charleston, South Carolina. Report completed December 1987, Published December 1989. SAFMC Technical Report Number 10, SAFMC Contribution Number 15, 18 pp.

Mattson, J.S. and J. A. DeFoor, III. 1985, Natural resource damages: Restitution as a mechanism to slow destruction of Florida's natural resources. J. Land Use Env. Law 1(3):295:319.

Reed, J.K. 1992 Submersible studies of Deep-Water Oculina and Lophelia Coral Banks off Southeastern U.S.A Proc. The American Academy of Underwater Sciences Twelfth Annual Scientific Diving Symposium. Sept 24-27, 1992. 143-151.

SAFMC 1988. South Atlantic Fishery Management Council. Amendment Number 1 and Environmental Assessment and Regulatory Impact Review to the Fishery Management Plan, for the Snapper Grouper Fishery of the South Atlantic Region.

SAFMC 1990. South Atlantic Fishery Management Council. Amendment Number 3 (Wreckfish), Regulatory Impact Review, Initial Regulatory Flexibility Analysis and Environmental Assessment for the Fishery Management Plan, for the Snapper Grouper Fishery of the South Atlantic Region.

SAFMC 1991. South Atlantic Fishery Management Council. Amendment Number 4 (Gear Restrictions and Size Limits), Regulatory Impact Review, Initial Regulatory Flexibility Analysis and Environmental Assessment for the Fishery Management Plan, for the Snapper Grouper Fishery of the South Atlantic Region.

SAFMC 1991. South Atlantic Fishery Management Council. Updated Source Document for the Snapper Grouper Fishery of the South Atlantic Region.

SAFMC 1993. South Atlantic Fishery Management Council. Amendment Number 6 (Commercial Trip Limits, Recreational Bag Limits, Gear Restrictions), Regulatory Impact Review, Initial Regulatory Flexibility Analysis and Environmental Assessment for the Fishery Management Plan, for the Snapper Grouper Fishery of the South Atlantic Region.

Sutherland, D.L. 1989. Mortalities of reef fish in traps. NOAA, NMFS, SEFC, Miami Laboratory, Coastal Resources Division Contribution No. CRD-88/89-03, 10 pp.

Sutherland, D.L., D.E.Harper 1983. The wire fish trap fishery of Dade and Broward counties, Florida December 1979 –September 1980. Fla. Mar. Res. Publ. No. 40,21 pp.

Taylor, R.G. and R.H. McMichael, Jr. 1983. The wire fish trap fishery Monroe and Collier counties, Florida. Fla. Mar. Res. Publ. No. 39, 19 pp.

9.2.5 Review of Management Measures and Proposed Next Steps

A review of existing fishery management measures as they relate to protection of EFH was provided in Section 1.4. The Council has a long history of protecting fish habitat. Area closure to trawling and dredging in the Bering Sea and Aleutian Islands area serve to protect HAPC from potential adverse impacts caused by these gear types. Other management measures were designed to reduce the impact of fishing on marine ecosystems. Catch quotas, bycatch limits, and gear restrictions control removals of prey species. Area closures around marine mammal rookeries and haulouts reduce fishery interactions with these predators.

Current research on the impacts of fishing gear on habitat was summarized in Section 9.2.2. Studies are being done to compare seafloor habitats in areas heavily trawled with areas that have had little trawl effort. Separate studies are underway in the GOA, Bering Sea, and Aleutian Islands.

The next step in this process (Phase 2) is to identify habitat areas of particular concern (HAPC) for each fishery management plan (FMP). The Alaska region has FMPs for Gulf of Alaska groundfish, BSAI groundfish, BSAI king and Tanner crab, Alaska scallops, and Alaska salmon. Proposals to amend the FMPs are being solicited to 1) identify HAPC, and 2) establish conservation measures to minimize, to the extent practicable, adverse impacts from fishing on HAPC. Additional details and guidelines for HAPC proposals were developed by the NMFS Core Team based on information supplied in Section 11 of this document. Copies of the guidelines are available from the Council office. In October 1998, the Council will prioritize the proposals and task staff with analyses. Final action on these amendments is scheduled for June 1999. Additional details of the proposal cycle are listed in Section 1.5.

9.3 Cumulative Impacts Analysis

The guidelines state that, to the extent feasible and practicable, FMPs should analyze how fishing and non-fishing activities influence habitat function on an ecosystem or watershed scale. This analysis should describe the ecosystem or watershed; the dependence of the managed species on the ecosystem or watershed, especially EFH; how fishing and non-fishing activities, individually or in combination, impact EFH and the managed species; and how the loss of EFH may affect the ecosystem**.** An assessment of the cumulative and synergistic effects of multiple threats, including the effects of natural stresses (such as storm damage or climate-based environmental shifts), and an assessment of the ecological risks resulting from the impact of those threats on the managed species' habitat should also be included. For the purposes of this analysis, cumulative impacts are impacts on the environment that result from the incremental impact of an action when added to other past, present, and reasonably foreseeable future actions, regardless of who undertakes such actions. Cumulative impacts can result from individually minor, but collectively significant actions taking place over a period of time.

Cumulative impacts from fishing. In addressing the impacts of fishing on EFH, Councils should also consider the cumulative impacts of multiple fishing practices and non-fishing activities on EFH, especially, on habitat areas of particular concern. Habitats that are particularly vulnerable to specific fishing equipment types should be identified for possible designation as habitat areas of particular concern.

Mapping cumulative impacts. A GIS or other mapping system should be used to support analyses of data. Maps depicting data documenting cumulative impacts identified in this paragraph should be included in an FMP.

Research needs. If completion of these analyses is not feasible or practicable for every ecosystem or watershed within an area identified as EFH, Councils should, in consultation with NMFS, identify in the FMP priority research areas to allow these analyses to be completed. Councils should include a schedule for completing such research. Such schedule of priority research areas should be combined with other EFH research needs.

The NPFMC and the Secretary of Commerce have taken appropriate actions when threats to fish habitat have been identified. These include cumulative effects from fishing activities and non-fishing activities. Cumulative effects have been examined in the Stock Assessment and Fishery Evaluation (SAFE) reports, which are produced annually for the crab, scallop, and groundfish fisheries. In addition, the plan teams prepare an Ecosystem Considerations Section to the SAFE reports. These reports identify specific ecosystem concerns that are considered by fishery managers for maintaining sustainability of marine ecosystems. The NMFS Alaska regional office has released for public review a supplemental Environmental Impact Statement (SEIS) for the Alaska groundfish fisheries that contains a description of all impacts due to fishing (NMFS 1998).

Cumulative impacts from non-fishing activities are monitored during the NMFS and State of Alaska permit review process. Development of habitat computer databases and GIS location maps will greatly assist this process. Coordination with other agencies will be required. For more information, see Section 6.0, containing NMFS recommendations on the description and identification of EFH.

Summary of Non-fishing Adverse Impacts to Habitat

Threats	HABITAT ALTERATION	Alternation of original or normal habitat	Loss of offshore habitat	Loss of pelagic habitat	Loss of nearshore habitat	Loss of benthic habitat	Loss of aquatic vegetaion	Loss of wetland value	Loss of original sediment type	Detrital matter introduction	TOPOGRAPHIC ALTERATION	Change in original feature or structure	Accretion \ Overburden of original feature	Erosion \ Dispersal of feature	ORGANISM ALTERATION	Physical damage to organism	Mortality	Spatial alteration	Gene pool deterioration	Introduction of exotic species	Introduction of pathogens\disease	Change in photosynthetic regime	OCEANOGRAPHIC ALTERATION	Change in temperture regime	Change in salinity	Change in circulation pattern	WATER QUALITY ALTERATION	Change in dissolved oxygen content	Eutrophication, nutrient loading	Water contamination	Suspended sediments, turbidity	Atmospheric deposition
Excavation																																
Dredging		X			X	X	X	X	X			X	X	X		X	X					X		*	*	*		*	X	X	X	
Dredge Material Disposal		X	X		X	X	X	X	X	X		X	X			X	X	X			X	X		*	*	*		*	X	X	X	
Marine Mining		X	X			X			X	X		X	X	X		X	X				X	X		X	X	X		*	X	X	X	
Nearshore Mining		X			X	X	X		X	X		X	X	X		X	X				X	X		*	*	*		*	X	X	X	
Recreational Uses																																
Boating				X	X	X	X			X						X	X			X	X			*	*	*		*	*	X	X	X
Stream Bank Over-usage		X						X	X	X		X	X	X		X	X				X	X							X	X	X	
Fish Waste Processing																																
Shoreside Discharge		X			X	X	X		X	X		X	X								X	X		X	X			*	X	X	X	
Vessel Discharge				X		X				X											X	X						*	X		X	
Aquaculture					X		X			X								X	X	X	X	X		X	X	X		*	X	X	X	
Petroleum Production																																
Production Facility		X	X		X	X	X	X	X	X		X	X	X			X	X			X	X		X	X	X				X	X	X
Exploration		X	X		X	X	X	X				X	X	X		X	X				X	X				X				X	X	X
Oil Spill		X	X		X	X	X	X	X	X						X	X		X		X	X			*			X		X	X	X
Hydrological																																
Hydroelectric Dams									X								X				X	X						X			X	
Impoundments		X					X	X	X			X	X	X		X	X				X	X						X	X		X	
Flood Erosion/Control		X			X		X	X	X			X	X	X		X	X					X						X	X			

Threats	HABITAT ALTERATION	Alternation of original or normal habitat	Loss of offshore habitat	Loss of pelagic habitat	Loss of nearshore habitat	Loss of benthic habitat	Loss of aquatic vegetaion	Loss of wetland value	Loss of original sediment type	Detrital matter introduction	TOPOGRAPHIC ALTERATION	Change in original feature or structure	Accretion \ Overburden of original feature	Erosion \ Dispersal of feature	ORGANISM ALTERATION	Physical damage to organism	Mortality	Spatial alteration	Gene pool deterioration	Introduction of exotic species	Introduction of pathogens\disease	Change in photosynthetic regime	OCEANOGRAPHIC ALTERATION	Change in temperture regime	Change in salinity	Change in circulation pattern	WATER QUALITY ALTERATION	Change in dissolved oxygen content	Eutrophication, nutrient loading	Water contamination	Suspended sediments, turbidity	Atmospheric deposition
Agricultural																																
Agriclutural/Farming		X			X		X	X	X	X		X	X	X				X			X			*	*			X	X	X	X	
Insect Control					X		X	X								X	X				X	X								X		X
Forestry		X			X		X	X	X	X		X	X	X		X		X				X		X	*					X	X	
Water Diversion/Withdrawl		X			X		X	X				X	X	X								X		*		X		X	X	X	X	
Harbors/Ports/Marinas																																
Port Construction		X			X	X	X	X	X	X		X	X	X		X	X	X				X		*	*	X		*		X	X	
Port Development		X			X	X	X	X	X	X		X	X	X		X	X	X			X	X				*		*		X	X	
Artifical Reefs		X			X	X						X	X	X				X				X		X	X	X						
Municipal and Industrial																																
Non-point Source				X	X	X	X	X	X	X			X			X	X	X	X		X	X		X	X			X		X		X
Coastal Urbanization		X			X	X	X	X	X	X		X	X	X		X	X	X	X	X	X	X		X	X	X		X	X	X	X	X
Sewage Treatment		X			X	X				X			X			X	X		X	X	X	X		X	X			X	X	X		
Storm Water Runoff					X					X						X	X		X	X	X	X		X	X			X	X	X	X	
Environmental																																
Climatic Changes/Shifts				X	X		X						X	X								X		X	X	X						X
Toxic Algal Bloom																X	X		X		X	X			*			X				
Introduction of Exotic Species																X	X	X	X	X	X								X			
Marine Transportation																																
Vessel Groundings		X			X	X	X		X	X		X		X		X	X			X	X									X		
Ballast Water				X		X										X	X		X	X	X	X		X	X					X		
Marine Debris		X		X	X	X	X		X	X			X			X	X	X			X	X								X		

* - short term impact

10.0 IDENTIFICATION OF RESEARCH NEEDS FOR EFH IN THE ALASKA REGION

The guidelines specify that each FMP should contain recommendations, preferably in priority order, for research efforts that the Councils and NMFS view as necessary for carrying out their EFH management mandate. The need for additional research is to make available sufficient information to support a higher level of description and identification of EFH. Additional research may also be necessary to identify and evaluate actual and potential adverse effects on EFH, including, but not limited to, direct physical alteration; impaired habitat quality/functions; cumulative impacts from fishing; or indirect adverse effects such as sea level rise, global warming and climate shifts; and non-equipment related fishery impacts. The Magnuson-Stevens Act specifically identifies the effects of fishing as a concern. The need for additional research on the effects of fishing equipment on EFH and a schedule for obtaining that information should be included in this section of the FMP. If an adverse effect on EFH is identified and determined to be an impediment to maintaining a sustainable fishery and the managed species' contribution to a healthy ecosystem, then the research needed to quantify and mitigate that effect should be identified in this section. The following excerpt from the draft NMFS paper entitled "Linking Fish Productivity to Habitat: An Initiative for FY 2000" provides an overview or research needs for EFH.

10.1 Overview of Habitat Research Needs

The Magnuson-Stevens Fishery Conservation and Management Act (M-SFCMA) as amended by the Sustainable Fisheries Act of 1996, is notable for its essential fish habitat (EFH) provisions. Implementing these provisions requires a program of research that will make available sufficient information to support a higher level of description and identification of EFH and to identify and evaluate actual and potential adverse effects on EFH, and to develop measures to conserve and enhance EFH. The ultimate goal of attaining a high level of description and identification of EFH is to directly link fish productivity to habitat. This concept will serve the nation in two important ways. It not only provides for the management of marine habitat via its protection, restoration and maintenance, but it also advances our objectives to provide sustainable fisheries. Increasing our understanding of how habitat affects the growth, reproduction, and survival rates of fish will ultimately improve our ability to predict changes in stock status, and will require the use of new, innovative technologies and development of predictive models. This knowledge will be used to provide for protection of presently undegraded habitat and make the necessary improvements to degraded habitats that will maintain and improve stock status. To move this objective beyond its conceptual stages will require commitment to advance our capabilities in three areas:

- I) Describe and identify essential fish habitat utilizing new and innovative technologies.
- II) Identify, describe, and understand the effects of adverse activities on essential fish habitat.
    - A) Identify, describe, and understand the effects of non-fishing related activities on essential fish habitat.
    - B) Understand the effects of gear and fishing activities on habitat.
- III) Develop methods and approaches to conserve and enhance essential fish habitat.

These areas are identified as major areas of information need in the National Marine Fisheries Service Habitat Research Plan (Thayer et al. 1996). The need for such a coordinated program of coastal and estuarine research is not only mandated by the M-SFCMA, but also was recognized by the National Academy of Sciences in their 1994 National Research Council Report on Priorities for Coastal Ecosystem Science which states that among the research areas requiring scientific information to eliminate shortcomings in our understanding of coastal habitat needs, functions, and processes are: relationships between habitat structure and function; recruitment and population and community development in both natural and restored ecosystems; processes that regulate and control interannual variability in populations; techniques, including the use of dredged material, for coastal habitat restoration; improved physical and biological models to help advance the design of ecosystem restorations.

The ultimate goal of the research described below is to link fish productivity to habitat. In concept it not only provides for the management of marine habitat via its protection, restoration and maintenance, but it also advances our objectives to provide sustainable fisheries. Objectives under this goal are to respond to the needs of the eight FMCs and NMFS by undertaking a program of research as required by the M-SFCMA to provide information to support increasingly more sophisticated levels of description and identification of EFH, to identify and evaluate actual and potential adverse effects on EFH (including both fishing-related and non-fishing related impacts), and to develop methods and approaches to conserve and enhance EFH. These objectives will be accomplished through: 1) enhanced biological sampling to complete life history distributions and abundances of managed species; 2) characterization and relating of benthic habitats to the distributions and abundances of managed species; 3) identification of habitat properties that contribute most to managed species' survival, growth, and productivity; 4) determination of habitat properties important in recruitment of managed species; 5) determination and evaluation of adverse effects on EFH from point and non-point sources, harmful algal blooms, hypoxia, endocrine disrupting chemicals, and pathogens; 6) identification of impacts of fishing gear on habitat of managed species; 7) testing of harvest refugia concept for selected areas and managed species; and 8) development of new methods and approaches for restoration of degraded EFH.

RESEARCH ACTIVITIES

The multi-species coastal and near shore research described here will be conducted with both conventional and new technologies. New technologies, such as multibeam sonar and others, and standardization of technologies are needed to assess and type deep benthic bottom habitat. The broad spatial extent of these fisheries generally has precluded careful examination of the nature of the exploited habitats, the relationships among species and habitats, and the degree to which fishing activities have affected these habitats. Other technologies, such as stable isotope analysis, insulin-like growth factor, and fatty acid analyses may be useful in establishing and confirming predator-prey relationships. Multiple stable isotopes as food web tags will be used to assess linkages between fishery organisms and habitats. Habitat related growth rates also will be examined using relatively new techniques based on microstructure of otoliths, RNA:DNA ratios, and cell-based growth measurements. Finally, remote sensing is important in providing a holistic view of landscapes covering large areas and monitoring changes in these landscapes which affect EFH and the living marine resources which reside there. Mapping of essential fish habitat will be conducted through synthesis of existing information and the development of GIS. We would expand on our use of submersible or ROV to transplant living coral and monitor coral settlement and growth and to document fish and invertebrate community changes in damaged and restored habitat.

I) Describe and identify essential fish habitat

Implementation of the M-SFCMA requires a program of research that provides information to support a higher level of description and identification of EFH. Research on the ecology of fish and their linkages with habitat is the foundation for such description and identification of EFH. The diversity, quality, and extent of habitats are among the most significant environmental determinants of distribution, abundance, and diversity of fishery resources. At present, the contribution of many of these habitats to the productivity of managed fishery species is unknown. Scientific information is required on the structure and function of fishery habitats to judge the impacts of threats to and provide recommendations to protect and restore habitats. To support description and identification of EFH, research is required to:

- Enhance biological sampling to complete life history distributions and abundances of managed species in the Alaska region. Identify and investigate inshore habitats of the Bering Sea that currently are not sampled, but are likely habitat for such important commercial species as king crab, flatfish, Pacific cod, and herring. Conduct biological surveys of continental slope habitats not adequately sampled for abundance and distribution of Eastern Bering Sea Greenland turbot, Gulf of Alaska shortraker and rougheye rockfish, and Dover sole. Utilize acoustic bottom typing to characterize bottom fish habitat in untrawlable areas in the Alaska region. Describe and understand habitat factors influencing distribution, abundance, growth, species interactions, and survival in order to forecast abundance trends and yield.

- Characterize benthic habitats in the Alaska region and relate to managed species biology. Identify and map continental shelf and slope benthic habitats (e.g., mud, sand, gravel, cobble, live bottom, etc.) in each NMFS region, as well as submerged reef and seagrass habitat where appropriate, using high resolution acoustic systems, submersibles and air and spaceborne remote sensing platforms. Conduct retrospective analyses of extant data on dominant species stratified by depth and latitude to relate habitat type and fish density. Use GIS to integrate bottom imagery (i.e., acoustic data) and other technologies with managed species data (i.e., distribution, abundance, and size) and determine relationships. Develop spatially explicit habitat models for demersal fishes.

- Identify habitats and habitat properties in the Alaska region that contribute most to managed species' survival, growth, and productivity. Determine the most productive habitats and watersheds for managed species. Conduct literature survey for habitat and life history information to develop habitat characterization and GIS maps for managed species in each region and develop a national GIS database. Develop and test laboratory and field techniques to measure habitat-specific survival, growth, reproduction, and production rates. Conduct habitat related growth and maturity investigations and food habitat studies using new technologies such as stable isotope and insulin-like growth factor analysis. Examine genetic parameters such as presence of rare alleles to determine the reproductive value of different habitats for major managed fish species. Examine the utility of using molecular genetics, biochemical and tissue indices of energy status of selected species as indicators of habitat quality. Conduct research on the growth and metabolic rates of larval and juvenile fishes as a function of salinity, temperature, and habitat type. Use GIS to analyze relationships between managed species and habitats. Develop individual-based models of populations and foodwebs.

- Determine importance of habitat properties in recruitment processes of managed species in all NMFS regions. Identify primary cues (e.g., temperature, salinity, currents, turbidity, habitat structure, habitat location or quality, and prey abundance) used by larvae and juveniles of commercially and recreationally important fisheries species for recruitment from oceanic spawning areas to coastal and estuarine habitats using remote sensing and field surveys. Identify factors regulating utilization of emergent and submergent coastal and estuarine habitats using field surveys, remote sensing, and such approaches as stable isotope analysis. Determine the importance of hydrographic, biotic, and structural components of the environment to the growth and survival of young of the year managed species that recruit to offshore banks. Identify the sources and sinks of managed species' production in the Alaska region, including identification of the origins of spawning adults and the fate of offspring spawned in various aquatic habitats. Utilize existing ichthyoplankton time series data (i.e., CALCOFI data) to determine fish production from inshore EFH in California. Use GIS and geostatistical analyses to develop models of EFH for estuarine dependent and continental shelf species, and develop spatial models that incorporate critical environmental features and which will provide management tools for FMCs.

II) Identify, describe, and understand the effects of adverse activities on essential fish habitat

Coastal ecosystems receive virtually all of the water flowing off the continental U.S. As human population increases, so do waste loads and use of the terrestrial surface. Changes in land use result in changes in land cover, which affect water quality and, subsequently, affects coastal and estuarine habitats and their living marine resources. Lack of understanding of the cumulative effects of land cover and changes in land cover on these habitats and their resources has limited the appropriate management of landscape activities. Additionally, in the U.S., as elsewhere, human population in the coastal region is increasing at an ever-quickening pace. Our ability to monitor resultant land cover and habitat change has not kept pace with the change, and management, thus, has been more reactive than proactive.

Mapping and monitoring of inshore (estuarine and riverine habitats of anadromous fish) EFH and determination of cumulative threats (i.e., adverse effects) and changes in those threats to EFH from non-fishing, land-based sources on watershed and regional scales has not occurred. Such information is required for management of fishery resources which migrate along our coasts and are affected by the numerous estuaries and rivers they occupy along the way. Thus, research is required to:

- Determine and map adverse effects of the watershed and regional changes in land cover on essential fish habitat. Utilize existing salmon and other managed species' abundance data and information on land use, water quality, hydrology and geology to determine non-fishing impacts at the ecosystem level employing a GIS/habitat modeling approach. Construct GIS database and maps on degradation of habitat quality by chemical contaminants. Develop regional GIS databases of permit related-activities, adverse impacts, and point source runoff information to assess potential hotspot areas along all coasts, including surveys of the current condition of culverts and bridges on logging roads crossing anadromous and high value resident fish streams. Overlay fishery resource information and conduct correlative and statistical analyses. Establish relationships between indices of habitat degradation and reductions in biological productivity and construct predictive models for use by FMCs. Predict the impact of coastal development activities on salmonid and other managed species' spawning and rearing habitats using GIS modeling techniques.

There is increasing concern among marine ecologists, resource managers, and fishery biologists over potential impacts of mobile fishing gear (e.g. bottom trawling and dredging) to essential benthic fish habitats. As fisheries expand, perceived and real damage to habitats is cause for even greater concern encompassing portions of the marine environment heretofore not considered, such as the deep shelf/slope. This type of disturbance can result in alteration of the physical complexity of benthic habitats, removing essential biological and sedimentary structure. Evidence of fishing activity can be clearly discerned in side scan sonar images of the seafloor. Acoustic analysis of groundfish habitats allows the mapping and quantification of these features in relationship to fishery and habitat distributions, and enables development of an index of benthic habitat disturbance caused by fishing activities. Comparisons also can be conducted on habitat recovery and community structure in areas closed to fishing relative to areas being fished. This would allow us to judge both impact to and recovery of habitats impacted by various gear types. We anticipate that a large-scale assessment of potential damaging effects to habitats by fishing activities could lead to improved habitat management and maintenance of the biological productivity of these fragile habitats. Thus, research is required to:

- Identify the impacts of mobile fishing gear on the continental shelf and the rate of recovery of these habitats after gear disturbance. Utilize side scan sonar, multi-beam acoustics, submersibles, video, and other new technologies to conduct large scale assessments in the Alaska region to evaluate effects on habitats by fishing activities. Conduct comparative evaluations in areas closed to fishing relative to similar areas being fished. Examine how different mixes of fishery management (e.g., gear exclusion) effects biodiversity and EFH over a wide variety of important habitats. Utilize existing data and retrospective analyses to evaluate if there have been changes in biodiversity, community composition, and size structure of fish populations in heavily trawled areas. Where impacts to habitat are observed that are statistically significant, conduct gear design research to minimize impacts. Via syntheses define and prioritize gear research needs that will minimize the adverse effects of fishing activities on EFH.

III) Develop methods and approaches to conserve and enhance essential fish habitat

Unfortunately, coastal marine and estuarine habitats are continuing to be lost through natural and man-induced causes. Approaches to minimization and conservation of essential fish habitats must continue to be sought. Identification of potential areas of refugia (i.e., research closure areas) and experiments on no take and limited take zones and time-area closures must be conducted as an evaluation of potential management approaches. Research is required on restoration methodology in order to counter and reverse the effects of habitat degradation and loss, and to develop measures for the conservation and enhancement of essential fish habitat. Technologies may exist to restore some habitats which, if done properly, have a chance of succeeding. However, creation, enhancement, and restoration of marine and estuarine habitats involves more than just capping of contaminated sediments, cultivating vegetation, breaching dikes, or nourishing beaches, for example. Limited methodologies exist for many habitat types and there has been little emphasis placed on rapidly restoring biodiversity and monitoring for success and persistence. Research also is needed to identify indicators of functional restoration, which may lag behind structural restoration of degraded habitats. NOAA with its stewardship for living marine resources has both the responsibility and capability to conduct such evaluations and implement the findings in its management decisions and its claims case responsibilities. Research will lead to scientific information on pathways of recovery and stability of created and restored habitats. Assessing new techniques and evaluating current technologies throughout geographic regions and scales will not only provide foundations for judging success but will generate guidelines for improving best management practices. A goal here is to return impacted systems to full productivity and biodiversity as efficiently and as economically as possible. Thus, research is required to:

- Develop and implement a scientifically valid experimental design to evaluate the best approaches to utilization of harvest refugia to manage, protect, and conserve Alaska rockfishes and other managed species. Synthesize existing information, identification of target species, potential sites, and assessment and monitoring requirements both within and outside the refugia. Evaluate potential fishery reserves in the Alaska region through mapping of spawning aggregations, determination of essential fish habitat and oceanographic features, and proximity to nearby nursery areas, using acoustic surveys and development of a GIS framework. Model source-sink dynamics of Alaska habitats through examination of ocean dynamics and larval distribution patterns. Develop spatially explicit models on important Eastern Bering Sea fishery organisms to provide management tools to conserve and sustain stocks.

- Evaluate new, innovative techniques directed at assessing functional value and restoration success of anadromous fish habitat, restored saltmarsh, seagrass, and shellfish reef habitats in all NMFS regions. Conduct comparative research on the impacts of urban development, agriculture, mining, and silvaculture on fishery habitats and evaluate restoration approaches that will include assessment of the role of buffer zones to ameliorate land use effects. Use comparative studies of restored and natural habitats to develop chemical and biological indicators of restoration. Determine the importance of patch size and proximity to adjacent habitats in the development of restored habitats. Develop simulation models based on field evaluations of the functional development of restored habitats to provide management recommendations on the most cost effective design, approaches, and specifications for habitat restoration. Conduct watershed level evaluations for areas of restoration opportunity/need on major systems on each coast.

EXPECTED PRODUCTS/BENEFITS

Products will support the description and identification of EFH as required under the M-SFCMA. Specific products for the Alaska region will include: enhanced life histories for managed species, particularly for eggs, larval, and juvenile stages inhabiting inshore and estuarine areas of Alaska, and adults inhabiting deeper shelf and slope waters of Alaska; detailed bottom habitat type maps entered into a GIS and related to managed species distributions and abundances; and identification of habitat factors contributing most to managed species survival, growth, productivity, and recruitment.

The link between habitat and fisheries productivity is poorly understood. These products will support the FMCs not only as a required element in the development of FMPs, but also in the conservation and enhancement of EFH for species managed under the M-SFCMA (i.e., Which habitats in what quantities and conditions are required to meet the long-term potential yields of managed species?). Improved understanding of fisheries habitats could lead to more accurate stock assessments and better conservation and management of fishery resources and the economic benefits derived from them.

Products will support the identification, description and understanding of non-fishing related adverse effects on EFH as required under the M-SFCMA. Products for the Alaska region include: GIS based maps of land cover and land cover change in 5 year increments to identify and locate, magnitude and change in landscape/watershed non-point sources affecting EFH; GIS databases of point sources affecting EFH; GIS based maps of managed species' habitat quality (indices of degradation), quantity and trends; GIS based analysis of relationships between habitat status and managed species' distribution, abundance, survival, growth, and productivity.

Non-fishing related adverse impacts to EFH are not well understood. Improved science is required to know which habitats in what quantities and conditions to protect in order to meet the long-term potential yields of managed species. Products listed above will enhance the FMCs ability to identify and understand non-fishery related adverse effects on EFH and to develop measures to conserve and enhance EFH of managed species. This research also will provide FMCs and NMFS with information to assess cumulative impacts and define when and where those impacts either are or will become unacceptable.

Products will support the identification and understanding of effects of gear and fishing activities on EFH as required under the M-SFCMA. Products for all NMFS regions include: detailed assessments of location and magnitude of gear impacts to benthic habitats of managed species, including changes in biodiversity and size structure of fish populations; information on comparisons between fished and non-fished areas and rates of recovery for areas impacted by bottom fishing gear.

The extent of impacts from fishing activities on seafloor habitat, benthic communities, and cover and food abundance for commercially valuable, managed species is unknown. Information on actual impacts would help decrease unnecessary contention among gear groups and assist the FMCs in making rational management decisions to reduce impacts as required by the M-SFCMA.

Products will support the development of methods and approaches to conserve and enhance EFH as required under the M-SFCMA. Products for all NMFS regions include: a synthesis of information regarding use and design of harvest refugia for managed species; new methods and approaches for the restoration of EFH; assessments of the role of buffer zones to ameliorate land use effects on EFH; development of indicators of degradation and recovery for EFH; and watershed evaluations for areas of restoration opportunity/need.

These products will strengthen the ability of the FMCs to develop measures to conserve and enhance EFH for inclusion within FMPs and to comment on federal and state activities that might adversely affect EFH. Additionally, these products will assist NMFS in developing recommendations during consultations required under the M-SFCMA to minimize or compensate for federal or state activities that might adversely EFH.

Conclusion

Alaska leads the Nation in fish habitat are and in the value of fish harvested, yet we lack the most basic information on distribution and habitat utilization for most early life stages of commercially valuable groundfish and shellfish. Systematic sampling exists only for targeted adults. A program is required to generate distributional data on which to determine EFH for the juvenile and larval stages of most or our marine fish. Additionally, Alaska fisheries are affected by two general anthopogenic impacts: (1) anthropogenic development that impacts watersheds, wetlands, estuaries, and nearshore benthic environment. Mapping and assessing impacted wetlands and eelgrass beds in an established GIS database with all salmonid producing streams (including riparian and upland land cover and use determinations) and escapements in the system is required to make necessary resource management decisions. Priority needs to be given to assessing and mapping high priority habitats, such as identifying and mapping eelgrass beds near roads and log dumps. Functional values of high-priority habitats need to be established, and the linkages between fishery productivity and habitats need to be understood. Fishing impact studies are in their infancy in Alaska. Increased emphasis needs to be placed on fish ecology and marine benthic habitat typing in conjunction with impact assessments of trawls, dredges, longlines, pot gear, and other fishing gear used in Alaska fisheries. Development of a standardized marine benthic habitat typing technology is a required precursor.

10.2 BSAI and GOA Groundfish FMP

The EFH Core Team developed a draft framework for evaluating research and management activities. The framework reflects the Team's strategy of organizing efforts and activities around the goals of protecting and managing habitat essential to productive fisheries. By evaluating current knowledge levels and status of EFH, priority research and management activities can be identified for the various FMPs. In applying the framework to groundfish, priorities are narrowed to where level 0 information for EFH intersects with habitats that are most at risk to human activities. The Team considered this intersection to be bottom habitats where groundfish fisheries take place as well as nearshore areas subject to shoreside and upland development. Specific research needs are:

- Information on habitat distribution, in conjunction with fish distribution is necessary to determine species habitat requirements and utilization. Information on the extent and distribution of complex habitat types easily impacted by bottomfishing will greatly improve the ability to evaluate the potential of a fishery to physically alter bottom habitat and evaluate proposed measures to minimize impacts on EFH. To attain this information we recommend increased support to evaluate remote bottom typing technology and increased application of currently available technology such as multi-beam sonar, that can provide detailed topographic maps of the continental shelf and slope.

- Surveys and studies of nearshore pelagic and benthic areas are needed to determine their use by a variety of species, including Atka mackerel, Pacific cod, pelagic rockfishes, sablefish, octopus, flatfishes, salmon, and juveniles and larvae of all species and forage species considered in NPFMC FMPs.

10.3 BSAI King and Tanner Crab FMP

As a first step to identify the most productive habitat types for each life stage of Bering Sea and Aleutian Islands king, Tanner and snow crabs, several analyses of existing data would be useful.

- Analyze trawl survey data to evaluate co-occurrence of crabs with flora, fauna, invertebrate and vertebrate species by survey station and year.
- Evaluate co-occurrence relative to changes in mature crab abundance and time lagged abundance as an index of recruitment.
- Investigate species interchange and niche displacement over time relative to crab and groundfish abundance by area.
- Evaluate relative crab and groundfish abundance by statistical area over time relative to intensity of commercial fishing effort.

Equally important is to ground truth assumed crab habitat associations by life stage and in so doing initiate regular surveys using appropriately scaled tools for the target sample space (e.g. oblique bongo tows, crab collectors, diver/submersible observation, beam trawl, and laser line scan). Regular survey allows estimation of prey usage, growth, reproductive potential and potentially natural and fishing mortality. Given the temporal nature of crab in time and space, multiple surveys spread throughout the year are important. Areas to focus survey sampling would include:

1. Established habitats associated with each life stage of crab by species.
2. Probable habitats for crab species and life stages of unknown habitat.
3. Known commercial fishing locations to assess abundance of bottom dwelling species and area of habitat types before and after a concentration of fishing gear occurs in the area.

Crabs exhibit a number of migratory behaviors throughout their life stages. Imperative to understanding changes in crab habitat association within a year and from life stage to life stage is development of scaled to size tags that can be retained through molt. To date no such tag exists for mature Chionoecetes crabs. Integral to a crab tagging program is sufficient technological support to track and recover tags.

10.4 Alaska Scallops FMP

The level of knowledge about the distribution, biology, life history, population dynamics of pink, spiny and rock scallops in Alaska is very poor. For weathervane scallops, limited information about biology and life history is available, and information about distribution is relatively good for adults but poor for other life stages. Accordingly, evaluations of fishery management strategies and potential impacts on Essential Fish Habitat of Alaskan scallops are data-limited. Highest priority research areas include (1) scallop biology and life history including spawning timing, ocean conditions favorable to early life survival, specific habitat features that determine scallop bed locations, and predators, (2) estimation of recruitment, mortality, and growth rates, (3) stock assessments, (4) population dynamics, (5) estimation of biological reference points as harvest controls, and (6) effects of dredge gear on scallop stocks, other invertebrate and fish species, and benthic habitats.

10.5 Alaska Salmon FMP

In applying the Core Team's framework to salmon, research priorities are focused on two activities: 1) acquiring basic data on salmon distribution and life history for regions where these data are missing; and

2) acquiring knowledge and developing management tools for use in conserving or restoring habitat areas of particular concern (identified above). Based on the draft framework, the following research needs are considered to be the highest priorities:

- Increase the scope of survey data for presence/absence, habitat-specific utilizations, in areas where intensive development, current or planned, threatens salmon habitat.

- Digitize species distribution and life-history information in anadromous stream atlas for inclusion in SASpop GIS system. A one-time effort would allow efficient use of existing information for definition of EFH.

- Research into the habitat values for salmon of the identified Habitat Areas of Particular Concern. These include nearshore marine and estuarine areas with submerged or emergent aquatic vegetation and freshwater streams and lakes in areas under intensive development for urban, industrial, timber harvest, and other land uses.

10.6 Strategic Investment Framework

A STRATEGIC INVESTMENT FRAMEWORK FOR THE ALASKA REGION'S ESSENTIAL FISH HABITAT PROGRAM

Background

The Sustainable Fisheries Act amended the Magnuson Fishery Conservation and Management Act to require the description and identification of essential fish habitat (EFH) in fishery management plans. It also requires that adverse impacts of federally authorized fishing practices on EFH be minimized, and provides the opportunity for review of any actions authorized,
funded, or undertaken by other federal agencies that may have adverse impacts on EFH. Along with these increased requirements, the National Marine Fisheries Service (NMFS) anticipates that additional funds for fish habitat protection and research will be provided by Congress.

This document is to be used as a planning tool to identify priority needs. New funds may be directed toward programs and research projects designed to address those needs. Existing programs and projects may be evaluated according to their responsiveness to identified needs.

GOAL: Ensure sufficient habitat to sustain fisheries at current levels (or increased levels where appropriate).

PRINCIPLES:

1. Adequate, high-quality fish habitat is essential to production of optimum yields of managed fish species.
2. Protection of fish habitat is an integral part of NMFS science and management responsibilities.
3. Adverse impacts to EFH by federally managed fisheries is a direct NMFS responsibility.
4. Habitat conservation programs will be developed using an ecosystem context.
5. The Magnuson-Stevens Act EFH project review program will be used in conjunction with the National Environmental Policy Act, Clean Water Act, and Federal Power Act project review programs, as well as the Sustainable Fisheries and Protected Species management programs.
6. NMFS will provide information to other agencies to conserve and enhance EFH, and recommend measures to mitigate adverse impacts on EFH.

Four objectives were identified toward achieving the goal for the EFH program. Each objective is associated with strategies and investments necessary for its achievement. The terminology follows the NMFS guidelines for identification of EFH. The fish species receiving EFH descriptions are those which are listed as target species in Department of Commerce approved fishery management plans, as well as Pacific halibut.

OBJECTIVE I. Describe and Identify EFH in fishery management plans.

Strategies:

A. Describe essential fish habitat for appropriate fish species in the Alaska Region.
Investments: (1) Review the literature and analyze unpublished information. (2) Depict EFH locations by species and life history stage on maps.

B. Obtain presence/absence information by life history stage for species and locations that presently are poorly known.
Investments: (1) Conduct research to determine presence/absence information by life history stage. (2) Amend EFH descriptions and maps with new information.

C. Develop and refine knowledge of marine habitat in the North Pacific Ocean.
Investments: (1) Conduct surveys to determine bottom type of marine benthic habitat where bathymetric maps are unavailable. (2) Standardize bottom type information and create maps with survey data.

D. Conduct research to fill information gaps in EFH descriptions.
Investments: (1) Conduct research to describe EFH by life history stage. Obtain data on little known life history stages of marine species. (2) Amend EFH descriptions and maps with new information.

OBJECTIVE II. Describe and identify habitat areas of particular concern by determining habitat function, distribution, and vulnerability to habitat alterations.

Strategies:

A. Compile and assess knowledge on distribution of habitats.
Investments: (1) Catalog available maps (e.g., NOS catalogs), existing data, literature review, and analysis of unpublished information. (2) Conduct surveys of habitats in areas where information is unavailable and produce maps for these areas.

B. Compile and assess knowledge on habitat function: Identify specific habitat parameters that are critical for survival of a species life stage to the next life stage. Habitat parameters include, but are not limited to: spawning substrate, egg-attachment substrate, species associations, feeding habitat, habitat used for protection from predators, or aspects of the physical environment (surge, light, salinity, etc.), preferences for freshly disturbed substrate or preference for substrate with fauna in climax state.
Investments: (1) Review the literature and analyze unpublished information. (2) Conduct research to determine habitat dependancies by life history stage.

C. Identify type and location of habitats vulnerable to loss or impairment by anthropogenic actions.
Investments: (1) Conduct research to determine effect of disturbance by trawl gear on biological substrate, resuspension of sediment by trawl gear, and reduction of complexity and diversity in benthic environment due to frequency of disturbance. (2) Conduct research on anadromous fish and crab species to determine effect of conversion to uplands of eelgrass beds and other intertidal and

subtidal habitat in coastal waters. (3) Utilizing results of II.A and B above, determine where HAPC is vulnerable to adverse impacts from anthropogenic activity.

OBJECTIVE III. Minimize habitat impact by managing human activities.

III.1. FISHING ACTIVITIES

Strategies:

A: Eliminate or decrease fishing activities known to adversely impact habitat of particular concern.
Investment: Based on appropriate research results and available habitat distribution knowledge, propose necessary area, gear, and season regulations in EEZ and State fisheries.

B. Where research on fishing activity impacts on habitat is lacking or incomplete, manage fisheries to the extent practical to enhance understanding of and minimize impacts from fishing activities.
Investment: Based on available habitat fishery knowledge, solicit, evaluate, and enact proposals for precautionary measures to minimize adverse impacts on habitat from fishing activities, while allowing prosecution of the fishery.

III.2. NON-FISHING ACTIVITIES

Strategies:

A. Minimize loss and impairment of vulnerable habitats.
Investments: (1) Conduct Magnuson-Stevens Act EFH consultations recommending avoidance and or minimization of activities that alter habitat important to a life stage of a managed species. Activities deserving EFH consultations include: aquaculture practices, timber harvest and forest management, urban developments, road construction and maintenance, programs that concentrate and/or promote increases in human population, oil and gas exploration and development, mineral and metal mining, energy transport, hydropower development and production, and transportation of hazardous materials.
(2) Review water quality standards for opportunities to reduce chronic water pollution that alters habitat parameters required by specific life history stages of managed species. Advise management agencies of findings.
(3) Assist management agency (EPA) with determinations of upper limits for total maximum daily load limitations on waterbodies declared as impaired.

OBJECTIVE IV. Where habitat has been impaired, develop and implement recovery programs.

Strategies:

A. Restore degraded habitat where cost-effective and will result in higher exploitable biomass of a managed fishery species.
Investments: (1) Determine which fishery species could have a higher exploitable biomass if additional or higher-quality habitat were available to one or more life stages of the species.
(2) Determine recovery rate or conditions necessary for recovery. (3) Develop cost-effective techniques to restore impaired habitat. (4) Restore habitat where cost-effective. (5) Foster

cooperative community-based restoration programs. (6) Export habitat restoration technology to other Regions.

Contributors: Tamra Faris, Lowell Fritz, Jeff Fujioka, Cindy Hartmann, Norris Jeffrey, Michael Murphy, Stan Rice, Ramona Schreiber, Jeff Short, David Witherell, and Steven Zimmerman.

11.0 HABITAT AREAS OF PARTICULAR CONCERN

11.1 NMFS Guidance

The interim final rule specifies that FMPs should identify habitat areas of particular concern within EFH. In determining whether a type, or area of EFH is a habitat area of particular concern, one or more of the following criteria must be met:

- (i) The importance of the ecological function provided by the habitat.
- (ii) The extent to which the habitat is sensitive to human-induced environmental degradation.
- (iii) Whether, and to what extent, development activities are, or will be, stressing the habitat type.
- (iv) The rarity of the habitat type.

Habitat areas of particular concern are referenced throughout the interim final rule and the technical manual. The intent of habitat areas of particular concern is to identify those areas that are known to be important to species which are in need of additional levels of protection from adverse effects. Management implications do result from their identification. Habitat areas of particular concern are intended to determine what areas within EFH should receive more of the Council's and NMFS' attention when providing comments on Federal and state actions, and in establishing higher standards to protect and/or restore such habitat. Certain activities should not be located in areas identified as habitat areas of particular concern due to the risk to the habitat. Habitats that are at greater risk to impacts, either individual or cumulative, including impacts from fishing, may be appropriate for this classification. Habitats that are limited in nature or those that provide critical refugia or could provide refugia (such as sanctuaries or reserves) may also be appropriate. General concurrences may be granted for activities within habitat areas of particular concern, however, greater scrutiny is necessary prior to approval of the general concurrence. Habitat areas of particular concern may also be more appropriate for enhancement, based on their importance to a species.

Identification of habitat areas of particular concern will be more critical in some regions than others. For some species/lifestages, limited information has been collected on species distribution or abundance. Life history requirements, however, may be understood and habitat needs may be known. In these cases, regions may use habitat areas of particular concern to focus their consultative efforts in key areas, even when species distribution surveys are not yet complete. These areas should be identified during the first round of EFH amendments as practicable. Due to limited time or information, however, other regions should continue to develop this information for later revisions. Habitat areas of particular concern should eventually be identified for all FMPs.

In determining habitat areas of particular concern, consideration should be given to the sensitivity, exposure, rarity and the importance of the ecological function of the habitat. An example is provided in Table 11.1.

Once a habitat type has been designated as EFH, the assessment of vulnerability and ecological importance should be conducted. This will assist in determining whether the area should be identified as a habitat areas of particular concern. The following matrix is offered as an example of how such a decision could be made.

Table 11.1. Matrix for HAPC/ Vulnerability Assessment by Species: Juvenile Spotted Sea Trout

Essential Fish Habitat	Data Level	Sensitivity	Exposure	Rarity	Ecological Importance
Submerged aquatic vegetation	1	High	High	Medium	High
Emergent marsh grass	1	High	High	Low	High
Oyster reefs	1	High	High	Low	Medium
Mud and sand flats	1	Medium	Medium	Low	Low
Water quality	N/A	High	High	Low	Medium
Other	--	--	--	--	--

Vulnerable habitat can be defined as habitat that is susceptible to perturbation by natural or man-made events or activities. Further, vulnerability should be related to physical damage and removal and degradation of condition (quality). Physical damage and removal could be caused, for example, by anchors dragging through SAV. Degradation of quality could be caused by water quality conditions, for example, that impede reproductive success of submerged aquatic vegetation. Vulnerability must also be related to the functions or ecological value of a habitat for particular fishery species or life stage. Sensitivity is defined as the degree that a habitat feature is susceptible to being degraded by exposure to activities, events, or conditions. Exposure is defined as the probability that a habitat feature will be exposed to activities, events, or conditions that may adversely affect the habitat.

If sensitivity is rated as “high,” that habitat is highly sensitive to perturbation. A rating of “medium” means that the habitat is somewhat sensitive, and “low” means that there is little to no sensitivity to perturbation. Regarding exposure, “high” means that there is a high probability of the habitat feature being exposed to a perturbation, “medium” means there is a reasonable possibility of exposure, and “low” means there is little to no probability of exposure. Regarding rarity, “high” means the habitat feature is very rare, “medium” means that it is somewhat rare, and “low” means that it is common.

Note that the matrix does not account for current habitat quality. If only Level 1 data (presence/absence) have been used to identify the habitat as essential, another column could be added to characterize the habitat quality, if there are data to support such a characterization. Alternatively, such habitat quality data for species-specific habitat sites could be considered during the consultation process. Ecological importance represents the value of a habitat type to a species at a particular life stage, based on ecological function. SAV is important for shrimp as it provides shelter and food. Sand flats are less important, providing little shelter or food.

Other matrices may be developed to assess the vulnerability of habitat types to perturbations. The following is an example of an alternative matrix format (Table 11.2).

Table 11.2. Matrix for Vulnerability Assessment by Habitat Type: Submerged Aquatic Vegetation

Spotted Seatrout	Data Tier	Sensitivity	Exposure	Rarity	Ecological Importance
Eggs	1	High	High	Medium	Low
Larvae	1	High	High	Medium	Medium
Juveniles	1	High	High	Medium	High
Spawning	1	Medium	Medium	Medium	Medium
Adults	1	Medium	Medium	Medium	High
Other	--	--	--	--	--

Matrices such as the above examples could be used in the determination of habitat areas of particular concern. This would involve evaluating the ratings of vulnerability, considering the number or the weight of each determination (i.e., the number of “high” rankings or the importance of a particular “high” ranking). Using scientific judgment, certain areas or habitat types could be designated as habitat areas of particular concern.

The example matrices provided do not include an assessment of habitat vulnerability to natural phenomenon. Different habitats could be evaluated in relation to their vulnerability to natural perturbations, such as storms, earthquakes, or floods. Consideration should be given to how habitat vulnerability to natural phenomenon may interact with anthropogenic factors. Assessments such as these may be used in determining habitat areas of particular concern.

11.2 Complementary Criteria for the Identification of Essential Fish Habitat

Prepared by Jeffrey Short, Michael Murphy, and Charles O'Clair

The proposed rule for implementing the essential fish habitat (EFH) provisions of the Magnuson-Stevens Act includes criteria for EFH identification that emphasize species distributions, rather than habitats *per se*. The species considered are limited to those managed under a fisheries management plan (FMP), and EFH is determined separately for each species based on life-history habits. Five levels of increasingly precise EFH criteria are used to identify EFH, corresponding to increasing levels of knowledge regarding habitat use by FMP-managed species. The most restrictive criterion (Level 4) presumes knowledge of production rates of a species for each habitat type. Unfortunately, such detailed knowledge is unavailable for most target species.

At the other extreme, the least restrictive criteria (Level 0 and 1) correspond with the species general distribution. For Level 0, this is inferred from knowledge of habitat requirements and behavior, and the presumed distribution of habitats. Equally unfortunate, these criteria provide little information on the "essentiality" of habitats within the range of a species. The EFH criteria proposed here are an attempt to redress this deficiency of the Level-0 and Level-1 criteria, by placing more emphasis on habitat differences instead of species differences. The complementary criteria emphasize habitats that are used by multiple target species, and may be derived from the same information base necessary for Level-0 determinations. Use of the complementary EFH criteria is proposed when Level-0 information is all that is available, and an EFH determination that is more precise than the species distribution is desired.

We propose that habitats be classified hierarchically according to epibenthic depth, substrate type, energy level, etc. following Dethier's 1992 modification of the scheme initially presented by Cowardin et al. (1979). Although this approach excludes oceanographic features such as fronts that are clearly important fish habitats, it thereby places appropriate emphasis on habitat features that are vulnerable to long-term or irreversible damage from single human actions (such as physical burial from dredge and fill activities). Fronts and other oceanographic features, however, could be added to the classification system if necessary.

The complementary EFH criteria proposed here are explicitly constrained by practicality of implementation. These criteria will provide only a crude approximation of habitat priorities, but these priorities may be initially determined without additional field work, similar to the criteria of the proposed Rule. Results from future field work, however, may be readily incorporated into this habitat-based approach.

The complementary method is similar to the suggested method described in the Technical Guidance for identifying Habitat Areas of Particular Concern. The Technical Guidance should be consulted for further information on how to apply both methods.

Method for EFH Ranking

Step 1. Identification of Biogeographic Regions

The most important habitats for fish vary among the different marine biogeographic regions of the United States. For example, coral reefs are extremely productive and provide a complex of ecosystem functions for multiple FMP-managed species in the subtropical waters of the U. S., but are considerably less important in subarctic waters. The habitats identified in the following step therefore depend on the biogeographic region where they occur.

Step 2. Habitat Classification

A habitat classification scheme provides a consistent framework for organizing habitat uses. The scheme presented by Dethier (1992) has several advantages, and is recommended as a default choice. This scheme is readily adaptable to different biogeographic regions and deep-water habitats, it emphasizes physical substrates, and variants are already used by other NOAA programs such as the CoastWatch Change Analysis Program (cf. Kiraly et al. 1991).

Step 3. Identification of Habitats Used by FMP-Managed Species

Within each biogeographic region, habitats used for reproduction, early life-stage rearing, cover, or foraging for all FMP-managed species are compiled as a column of a habitat-use table (*e.g.* column 1, table 1). These habitats may be determined from the life-history literature of each species. Habitat use for reproduction, early life-stage rearing, cover, or foraging by FMP-managed species provide additional columns of the table.

Step 4. Habitat Use Determination

Habitat use is indicated on the habitat-use table for each FMP-managed species. All habitats that are used by each life-stage of a species are indicated by an entry on the table for all use categories (reproduction, rearing, cover, foraging). A particular habitat may therefore have multiple entries for reproductive use by some species, for cover by others, etc.

Step 5. Habitat Use Ranking

The habitat use rank is the sum of all the entries across use categories. Thus, the highest-ranked habitats are those used by the most species for the most numerous functions (see Table 11.3). . Other considerations, such as species or habitat rarity, could also be added to the matrix for ranking habitat importance.

<u>Prioritizing through Risk Assessment</u>

Managers and regulators often need to prioritize projects for scheduling interagency consultations, establishing research priorities, and other activities to efficiently direct efforts where most urgently needed. The proposed system of ranking habitat importance according to FMP species utilization described above provides one criterion for ranking priority. Also relevant are criteria relating to the level of management concern developed through a risk assessment.

The risk of impacts to a particular type of habitat is determined by its sensitivity to disturbance and the current level (scale and periodicity) of ongoing disturbance.   These factors can be combined to provide a measure of management risk for establishing priorities.

Environmental Sensitivity

The sensitivity of a given type of habitat to a disturbance regime depends on its ecological resistance (the ability to resist change during a disturbance) and resilience (the ability to return to its pre-disturbance structure) (Connel and Sousa 1983). Factors that contribute to ecological resistance are 1) redundancy in function of component species, 2) tolerance to environmental fluctuations, 3) physical and chemical buffering capacity or flushing characteristics, and 4) proximity of the system to its ecological limits (Cairns and Dickson 1977). Resilience has four components: elasticity, amplitude, hysteresis, and malleability (Westman 1978). Elasticity is the time required for recovery, amplitude defines the level of disturbance that allows recovery, hysteresis describes the "path" of recovery, and malleability is a measure of the plasticity of the system (i.e., its capacity to persist in an altered state) (Cintron-Molero 1992).

Although quantitative data on resistance and resilience may be unavailable for many habitat types, enough information and experience should be available to array the habitats within a relative ranking system. For example, mangrove systems are thought to have great resistance and resilience to disturbance (Cintron-Molero 1992), whereas coral reefs tend to be sensitive and recover slowly (Maragos 1992).

For each habitat type, one could assign an "Environmental sensitivity index" (ESI), which would represent the relative resistance and resilience under a particular disturbance regime (natural or anthropogenic). For example, resistance and resilience of types of bottom habitat to trawling impacts could be rated on a scale of 1 to 3, and the ESI could be calculated simply as the mean of the two ranks (**Table 12.4**). In this scheme, various combinations of resistance and resilience produce an ESI ranging from 1 to 3. Habitat types with low resistance and resilience have high environmental sensitivity, and habitats with high resistance and resilience have low environmental sensitivity.

Current Level of Disturbance

Another consideration in assessing risk is the habitat's current level of disturbance. For example, a higher risk is involved for a habitat type that has been impaired over a large percentage of its total area and is currently being disturbed at high annual rate than for a habitat that is mostly pristine and not being disturbed.

The current level of impairment or disturbance has two components: 1) the relative area of habitat that is impaired and 2) the ongoing rate of habitat disturbance. The relative area of impaired habitat is the estimated area of the particular habitat type that has been impaired by human activity divided by the total area of that habitat type in the biogeographic region. Ideally, this information would be taken from existing GIS maps. Where GIS data are not available, relative area disturbed could be estimated by professional judgement or proxy data, such as the proportion of coastline impaired versus the length of coast containing the particular habitat. The rate of habitat disturbance is the percentage of habitat disturbed each year (e.g., the percentage of total area of a habitat type that has been disturbed over the past decade divided by 10).

These two components--the percentage area impaired and the ongoing rate of disturbance--can be combined to give an index of the current level of habitat disturbance. For example, one could multiply the percentage area impaired times the percentage rate of disturbance, in which case, the "disturbance level score" would range from 0 (0% impaired, no ongoing disturbance) to 10,000 (100% impaired, 100% disturbed per year). For purpose of ranking habitats by priority, the disturbance level scores could be grouped (e.g., low, medium, and high) to provide an index with comparable weight to the index for environmental sensitivity (**Table 12.5**).

Management Priority Ranking

Finally, the habitat type's environmental sensitivity index, disturbance level index, and importance rank, could be combined and used as a guide for prioritizing research, interagency consultations, and other management activities. One could obtain a priority ranking by multiplying the indices and importance rank (as in last column in Table 11.3). This approach provides a means for focusing agency efforts toward the most important types of habitat that are also the most sensitive to environmental impacts and with the highest current level of ongoing disturbance.

Table 11.3. *Pro forma* example of a habitat-based approach to assessing and prioritizing Essential Fish Habitat. Habitat sub-types discriminated by dominant biota are omitted for simplicity.

Habitat Type	FMP Species Utilization				Risk Indices		Management Priority Index[c]
	(X_1) Spawning (*No.*)	(X_2) Early Life (*No.*)	(X_3) Etc. (*No.*)	Habitat Rank ($3X_i$)	Environmental Sensitivity Index[a]	Disturbance Level Index[b]	
2	10	10	10	30	3	1	90
3	10	10	10	30	1	3	90
4	10	10	10	30	1	1	30
Sublittoral Cobble	0	1	0	1	3	3	9
Sublittoral Gravel	1	0	0	1	3	1	3
Sublittoral Sand	0	0	1	1	1	1	1
etc.							

[a] Calculated in Table 11.4 based on evaluation of the habitat type's resistance and resilience in the context of the prevailing disturbance regime.
[b] Calculated in Table 11.5 based on percentage habitat area currently impaired and current rate of habitat disturbance.
[C] Product of Habitat Rank and Risk Indices.

Table 11.4. Example of an approach for rating habitats for environmental sensitivity.

Habitat Type	Resistance	Resilience	Environmental Sensitivity Index[a]
1	3 = Low	3 = Low	3 = High
2	1 = High	1 = High	1 = Low
3	1 = High	3 = Low	2 = Intermediate
etc.			

[a]Mean of resistance and resilience scores.

Table 11.5. Example of an approach for rating habitats according to current level of disturbance.

Habitat Type	% Area Impaired	% Impaired per Year	Disturbance Level Index[a]
1	Low	Low	Low = 1
2	Low	High	Intermediate =2
3	High	Low	Intermediate =2
4	High	High	High = 3
etc.			

[a] Combines second and third columns as a rank.

Literature Cited

Cairns, J., Jr. and K. L. Dickson. 1977. Recovery of streams and spills of hazardous materials, pages 24-42 in J. Cairns, Jr., K. L. Dickson, and E. E. Herricks (eds.), Recovery and restoration of damaged ecosystems. University of Virginia Press, Charlottesville.

Connel, J. H., and W. P. Sousa. 1983. On the evidence needed to judge ecological stability or persistence. American Naturalist 121:789-824.

Cowardin, L. M., Carter, V., Golet, F. C. and LaRoe, E. T. 1979. Classification of wetlands and deepwater habitats of the United States. U. S. Fish and Wildlife Service, Office of Biological Services Publication USFWS/OBS-79/31. U. S. Government Printing Office, Washington D. C.

Cintron-Molero, G. 1992. Restoring mangrove systems, pages 223-277 *In* G. W. Thayer (ed.), Restoring the Nation's marine environment. Maryland Sea Grant College Publication UM-SG-TS-92-06.

Dethier, M. N. 1992. Classifying marine and estuarine natural communities: an alternative to the Cowardin system. Natural Areas Journal 12:90-100.

Kiraly, S. J., Cross, F. A., and Buffington, J. D. 1991. The Federal effort to document trends in coastal habitat loss. NOAA Technical Memorandum CS/NOPPO 91-1.

Maragos, J. E. 1992. Restoring coral reefs with emphasis on Pacific reefs, pages 141-221 *In* G. W. Thayer (ed.), Restoring the Nation's marine environment. Maryland Sea Grant College Publication UM-SG-TS-92-06.

Westman, W. E. 1978. Measuring the inertia and resilience of ecosystems. BioScience 28:705-710.

11.3 Preliminary Application of the Complementary Criteria Approach to Identifying EFH for Bering Sea Groundfish

Prepared by Jeff Short, Adam Moles, and Mike Murphy

This is an initial attempt to apply the complementary criteria approach to identifying EFH for Bering Sea and Aleutian Islands groundfish. It is based on available data contained in the Preliminary Essential Fish Habitat Assessment Report for the Groundfish Resources of the Bering Sea/Aleutian Islands Region prepared by the Technical Team for Essential Fish Habitat for Groundfish in the Bering Sea and Aleutian Islands. For the purpose of this initial exercise, habitat types were taken as the broad categories used in the technical team's report because a habitat classification system for off-shore habitats has not yet been developed.

In the following table, utilization of the various habitat types is indicated for each major life stage of FMP-managed groundfish, based on descriptions in the technical team's Report. The sum of the number of life stages utilizing each habitat type provides a score which can indicate the relative importance of the various habitat types as EFH. This exercise is considered preliminary because of the lack of detail in the habitat classification and limited data on habitat utilization for many of the habitats and species.

Based on this preliminary analysis, the Complementary Criteria approach to assessing EFH shows promise in establishing the relative importance of various habitat types over a wide range of FMP-managed species and locales. Results suggest the importance of soft-sediment demersal habitat. Over 50% of the total scores in Table 11.6 were for species and life stages found in demersal habitat. Similarly, 83% of the scores among demersal species or life stages for which bottom type (Table 11.7) is known were from fine-grained sediments (some mixture of mud, sand, or granule). The Complementary Criteria approach may be most useful where habitat information is the most detailed, such as among nearshore habitats where information about bottom type, food, predators, current, temperature, and salinity can provide additional separation.

Further analysis including an estimate of the habitat type's environmental sensitivity and disturbance level could provide a guide for prioritizing EFH efforts. For example, soft-sediment demersal habitats rank high in species utilization and are probably also especially sensitive to disturbance, indicating they should be a high priority for research and other EFH efforts.

Discussion

For the purposes of habitat classification, Bering Sea groundfish can be conveniently divided into three categories: pelagic fishes living near the bottom of the continental shelf, demersal fishes, and fishes living in benthic sediments.

Offshore pelagic fishes such as walleye pollock, the larvae of most groundfish species, squid, sharks, eulachon and juveniles of both mackerel and rockfishes share a distribution defined more by the presence of currents, prey, and oceanographic features rather than bottom or shore type. If human activity other than fishing is likely to have any impact on these offshore, it would be in altering the prey field for these fishes. These fishes spend little time in close association with either the bottom or shore to be impacted by either pollution or habitat alteration. For these species, research needs to concentrate on the habitat requirements of their prey. If a significant amount of their prey require benthos or nearshore residence, human activity such as trawling, pollution, or dredging could reduce the food available to offshore species.

Demersal fishes, in contrast, often have specific habitat requirements. At present, most of our knowledge of bottom type comes from grain size observations made during collections. Fish such as Pacific cod, sablefish juveniles, and capelin adults as well as squid seem to prefer fine grained sediments whereas mackerel adults prefer rocky bottoms. Cottids and octopi have been reported for nearly all types of bottoms. Whether rockfishes, skates, sleeper sharks and sablefishes have any distinct grain size preferences is unknown. These bottom types may be preferred because they harbor the preferred prey or may just reflect the bottom type suitable for trawling. Research should concentrate on sediment preferences among these fishes and impacts of trawling on those sediments.

Flatfishes, living in intimate contact with sediments, have specific and known preferences for fine grained sediments at all life stages. Juveniles rear in nearshore protected bays and estuaries on sediments sufficiently fine to enable burial. For flatfishes, the number of fish recruiting to the fishery is thought to be determined during the first 2 years of the juvenile stage, a time when the fish are putting on initial growth close to shore. The intertidal and subtidal zones are particularly susceptible to anthropogenic alterations, such as industrial runoff, pollution, construction, and marine debris.

The Dethier system for habitat classification was designed for nearshore habitats which can be conveniently inventoried by bottom type, currents, and tidal activity. Application of such fine tuning to offshore habitats may be impractical given the direct correlation between bottom type and trawling activity and lack of knowledge of other habitat parameters in the deep waters. In addition, some FMP-managed species complexes are either too ubiquitous (e.g., cottids) or we know too little about the life history (e.g., some sharks) for a classification system to work effectively on these species. For nearshore demersal species, however, the Dethier system has the potential for providing quantitative information about habitat utilization.

Table 11.6. Habitat utilization by major life stages of Bering Sea Groundfish.

Number of species/stages occurrence by habitat type.

			Life Stage			Total
Habitat Type	Eggs	Larvae	Juv.	Late Juv.	Adult	Score
Intertidal	2	1	-	-	2	**5**
Estuarine Subtidal	1	2	5	2	3	**11**
Inner Shelf Neustonic	-	2	1	-	-	**3**
Inner Shelf Pelagic	2	6	3	1	1	**13**
Inner Shelf Midwater	-	-	1	2	2	**5**
Inner Shelf Demersal	2	-	7	5	8	**22**
Middle Shelf Neustonic	-	2	1	-	-	**3**
Middle Shelf Pelagic	1	5	4	2	1	**13**
Middle Shelf Midwater	-	-	1	2	2	**5**
Middle Shelf Demersal	2	-	4	2	7	**15**
Outer Shelf Neustonic	-	1	1	-	-	**2**
Outer Shelf Pelagic	3	6	3	2	2	**16**
Outer Shelf Midwater	-	-	1	2	3	**6**
Outer Shelf Demersal	3	-	6	5	8	**22**
Upper Slope Neustonic	-	-	-	-	-	-
Upper Slope Pelagic	1	1	1	1	-	**4**
Upper Slope Midwater	-	-	-	-	-	-
Upper Slope Demersal	1	-	3	-	6	**10**
Lower Slope Neustonic	-	-	-	-	-	-
Lower Slope Pelagic	1	1	-	-	-	**2**
Lower Slope Shelf Midwater	-	-	-	-	-	-
Lower Slope Demersal	1	-	-	-	3	**4**
Basin Neustonic	-	1	-	-	-	**1**
Basin Pelagic	1	1	-	-	-	**2**

Basin Midwater	-	-	-	-	-	-
Basin Demersal	-	-	-	-	-	-

Table 11.7. Habitat utilization scores for Bering Sea groundfish.

Habitat Type	**Eggs/Larvae**	**Juveniles**	**Adult**	**Score**
Marine Intertidal				
Rock	-	-	-	**-**
Mixed Coarse	1	-	1	**2**
Gravel	-	-	-	**-**
Fines	2	2	2	**6**
Mud	-	-	-	**-**
Marine Subtidal				
Unknown	1	1	1	**3**
Rock	-	-	-	**-**
Mixed Coarse	-	-	-	**-**
Gravel	-	-	-	-
Fines	1	2	3	**6**
Mud	-	-	-	**-**
Estuarine Intertidal				
Unknown	-	-	-	**-**
Rock	1	-	1	**2**
Mixed Coarse	-	-	-	**-**
Gravel	-	-	-	**-**
Fines	2	2	2	**6**
Mud	-	-	-	-
Estuarine Subtidal				
Unknown	1	1	1	**3**
Rock	-	1	-	**1**
Mixed Coarse	-	-	-	**-**
Gravel	-	-	-	**-**
Fines	1	2	3	**6**

Table 11.7. Continued.

Habitat Type	Eggs/Larvae	Juveniles	Adult	Score
Inner Shelf Demersal				
Unknown	1	1	2	**4**
Rock	1	-	1	**2**
Mixed Coarse	1	-	-	**1**
Gravel	-	-	-	-
Fines	1	7	4	**12**
Mud	-	-	-	-
Middle Shelf Demersal				
Unknown	2	2	3	**7**
Rock	-	-	1	**1**
Mixed Coarse	-	-	1	**1**
Gravel	-	-	-	-
Fines	1	3	2	**6**
Mud	-	-	-	-
Outer Shelf Demersal				
Unknown	3	2	4	**9**
Rock	-	-	1	**1**
Mixed Coarse	-	-	1	**1**
Gravel	-	-	-	-
Fines	1	6	4	**11**
Mud	-	-	-	-
Upper Slope Demersal				
Unknown	1	2	4	**7**
Rock	-	-	-	-
Mixed Coarse	-	-	-	-
Gravel	-	-	-	-
Fines	1	2	2	5
Mud	-	-	-	-
Lower Slope Demersal				
Unknown	-	1	2	**3**
Rock	-	-	-	-
Mixed Coarse	-	-	-	-
Gravel	-	-	-	-
Fines	1	-	1	**2**

11.4 Habitat Areas of Particular Concern in Alaska

There are several habitat types in Alaska that meet all of the criteria specified in the interim final rule. These habitat types have important ecological functions, are sensitive and vulnerable to human impacts, and are relatively rare. A summary of these habitat types is provided below.

11.4.1 Living Substrates in Shallow Waters

Habitat areas of particular concern include nearshore areas of intertidal and submerged vegetation, rock, and other substrates. These areas provide food and rearing habitat for juvenile groundfish and spawning areas of some species (e.g., Atka mackerel, yellowfin sole), and may have a high potential to be affected by shore-based activities.

Shallow inshore areas (less than 50 m depth) are very important to king crab reproduction. After molting through four larval (zoea) stages, king crab larvae develop into glaucothoe which are young crabs that settle in the benthic environment in nearshore shallow areas with significant cover, particularly those with living substrates (macroalgae, tube building polychaete worms, kelp, mussels, and erect bryozoans). The area north and adjacent to the Alaska peninsula (Unimak Island to Port Moller) and the eastern portion of Bristol Bay are locations known to be particularly important for rearing juvenile king crab.

All nearshore marine and estuarine habitats used by Pacific salmon, such as eel grass beds, submerged aquatic vegetation, emergent vegetated wetlands, and certain intertidal zones, are sensitive to natural or human induced environmental degradation, especially in urban areas and in other areas adjacent to intensive human-induced developmental activities. Many of these areas are unique and rare. The coastal zone is under the most intense development pressure, and estuarine and intertidal areas are limited in comparison with the areal scope of other marine habitats for salmon.

Herring also require shallow water living substrates for reproduction. Spawning takes place near the shoreline between the high tide level and 11 meters. Herring deposit their eggs on vegetation, primarily rockweed (Fucus sp.) and eelgrass (Zostera sp.). These “seaweeds” are found along much of the Alaska coastline, but they often occur in discrete patches.

11.4.2 Living Substrates in Deep Waters

Habitat areas of particular concern include offshore areas with substrates of high-micro habitat diversity, which serve as cover for groundfish and other organisms. These can be areas with rich epifaunal communities (e.g., coral, anemones, bryozoans, etc.), or with large particle size (e.g., boulders, cobble). Complex habitat structures are considered most readily impacted by fishing activities (see previous sections of this document).

Corals are generally considered to be very slow growing organisms, and are a habitat of particular concern. Although scientists are not quite sure of coral's importance to fish habitat, it would certainly provide vertical structure for fish to use for protection and cover. Some observations to this claim have been provided by submersible observations. Coral habitat is likely very sensitive to human-induced environmental degradation from both fishing and non-fishing threats. It is not known how much coral there is off the coast of Alaska, but it is likely to be rare relative to other habitat types.

There are several species of deepwater coral found off Alaska. Two common species are red tree coral (Primnoa willeyi) and sea raspberry (Eunephtya sp.). Although these corals are thought to be distributed throughout the Gulf of Alaska and Aleutian Islands, much of the data analysis has focused on the eastern Gulf of Alaska. NMFS trawl surveys have indicated high concentrations in the immediate vicinity of Dixon Entrance, Cape Ommaney, and Alsek Valley (Draft EA for Amendment 29 to the GOA Groundfish FMP, September 1992). In the GOA, NMFS surveys have taken red tree coral in very deep areas (125-210 fathoms), whereas sea raspberries have generally been taken in shallower areas (70-110 fathoms).

Information on coral distribution has been summarized in a 1981 report by R. Cimberg, T. Gerrodette, and K. Muzik titled, "Habitat Requirements and Expected Distribution of Alaska Coral." Though this report was written in the context of potential impacts of oil and gas exploration and development, information on habitat and distribution is relevant for our purposes. Though the report discusses coral distributions throughout Alaska, the focus here is on the information contained relevant to southeast Alaska.

The study notes that this Region probably has the largest number of coral species due tot he variety of habitats in terms of depth, substrate, temperature, and currents. Primnoa, or red tree corals, are more abundant in southeast Alaska than in any other region. Other species of fan corals have been observed as well as bamboo corals, cup corals, soft corals, and hydrocorals. The greatest number of distributional records for red tree corals are from the Gulf of Alaska, in particular from the inside waters of southeast Alaska. In southeast Alaska, red tree corals have frequently been reported in Chatham Strait, Frederick Sound, and Behm Canal. The frequency of occurrences increases toward the ocean entrances and further away from the fjords. This trend is likely due to swifter currents near the entrances and/or greater turbidity and lower salinities in the fjords. Areas of highest densities are found in regions where currents are 3/4 knots.

Distributional records were additionally analyzed relative to the depths at which they occurred. Red tree corals have been reported at depths from 10 to 800 m. The lower depth limit varied in different regions of Alaska, increasing along a geographic gradient from the Aleutians to southeast Alaska. The lower depth limit of these corals in each area corresponds with a mean spring temperature of 3.7 degrees C. The report indicates that in southeast Alaska there is a difference in the lower depth limit exhibited north of 57E latitude and that experienced south of that line (roughly running through Sitka). The data from the report indicate that, in the area of southeast Alaska north of 57E, red tree corals are predominately found between 50 and 150 meters in depth. Significant occurrences continue to exist from 150 to 250 m, and taper off rapidly beyond 250 m. South of the 57E line, they occur over a broader depth range with equal occurrences from 50 to 450 m. The report indicates that other species of sea fans may be found deeper than Primnoa, at depths up to 2,000 m.

Bamboo corals also occur in the waters of both the inside passages of southeast Alaska and in the southeast Gulf of Alaska. These corals have a lower temperature tolerance, about 3.0 degrees C, and exist in depths from 300-3,500 m. These corals are also expected to exist in a rocky, stable substrate and have a low tolerance for sediments.

The depth distribution of soft corals is, like the red tree corals, expected to range from 10-800 m, though they may exist on a much wider range of substrates. Hydrocorals, also occurring in southeast Alaska, have a depth range of 700-950 m, though they may occur at shallower depths in southeast Alaska than in the more northern, colder waters.

The report notes (again in the context of potential disturbance by oil and gas exploration and development) that recolonization of tropical coral communities requires at least several decades to recover from major perturbations. Alaskan corals would likely take much longer to recolonize following similar disturbances. For example, given a predicted growth rate of 1 cm/year for Primnoa, a colony 1 m high would require at least 100 years to return to the pre-impacted state. This, of course, is regardless of the origin of the impact.

11.4.3 Freshwater Areas Used by Anadromous Fish

Habitat Areas of Particular Concern also include all anadromous streams, lakes, and other freshwater areas used by Pacific salmon and other anadromous fish (such as smelt), especially in urban areas and in other areas adjacent to intensive human-induced developmental activities.